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FINAL REPORT
DESIGN AND MANUFACTURE OF STATIC INVERTER FOR BRAYTON POWER CONVERSION SYSTEM

by

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FOREWORD

The work described in this report was performed at Gulton Industries, Inc., Engineered Magnetics Division, for the Borg-Warner Corporation, Pesco Products Division, as authorized by NASA Contract NAS3-10935. The Project Manager for Pesco Products Division was Mr. L. E. Gebacz. Mr. G. H. Ribble of the Space Power Systems Division, NASA-Lewis Research Center, was the NASA Project Manager with technical assistance from Mr. J. H. Shank.

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ABSTRACT

The Static Inverter converts and conditions available DC power to 400 Hz quasi-square wave power to drive the pump motor assembly in the coolant loop of the Brayton Power Conversion System. The Static Inverter has a tested efficiency of 94% and a calculated Mean Time Between Failure of 88511 hours.

The report contains a text of the theory of operation, electrical and mechanical design drawings, reliability calculations, parts selection, stress analysis, thermal calculations, and typical test results.

SUMMARY

The NASA Lewis Research Center is currently engaged in a Brayton space power technology program. The Brayton Power Conversion System (PCS) has applicability for solar, radioisotopes, and nuclear space power systems. The initial demonstration system has a net output power range of 2.25 to 10.5 kW at 1200 Hertz. The Brayton PCS is designed to operate unattended in space for five (5) years.

The Static Inverter Program was conducted at Gulton Industries, Inc., Engineered Magnetics Division, under a sub-contract for the Borg-Warner Corporation, Pesco Products Division. This program included the design, development, fabrication, testing, and delivery of seven Static Inverters.

A portion of the 1200 Hertz Brayton PCS electrical output is converted to DC power. The Static Inverter inverts and conditions this available DC power (50 to 60 VDC) to 400 Hertz quasi-square wave power to drive the pump motor assembly in the coolant loop of the Brayton PCS.

Judicious circuit design, including the Gulton patented "RIPPLE REGULATOR" enabled the Static Inverter to attain an efficiency of 94%. With the use of Ultra-High Reliability components, the calculated Mean Time Between Failure of the Static Inverter is 88511 hours.

This report contains a text of the theory of operation, electrical and mechanical design drawings, reliability calculations, parts selection, stress analysis, thermal calculations, and typical test results.

This program was conducted with a minimum of design, fabrication, and testing problems. The Static Inverter meets or exceeds all requirements of the Static Inverter Specification.

INTRODUCTION

The EMIU104D Static Inverter converts and conditions available DC power (50 to 60 VDC) to the specific requirements of the pump motor assembly for use in a Brayton Power Conversion System. There were no major problems encountered during the design, development, or fabrication phases of the program. Problems that did occur were overcome by accomplishing electrical or mechanical design changes to the unit.

During the preliminary design phase of the program, design and assembly details defining operating parameters and design envelope for Engineered Magnetics Model EMIU104D Static Inverter were accomplished, a satisfactory baseline was established, and preliminary schematic drawings of the Static Inverter were obtained. Engineered Magnetics Quality Program Plan and Reliability Program Plan for Static Inverter EMIU104D were written and submitted to Pesco Products.

The mechanical design of the Static Inverter was defined and sufficient work was accomplished to determine that no major problems existed in the areas of heat transfer, mounting position, or packaging of the Inverter. A preliminary reliability estimate was calculated for the component parts of the Static Inverter. The reliability estimate was revised and updated after finalization of the Inverter design was accomplished.

The Inverter mounting base is designed to interface with a separate coldplate. Inverter cooling is accomplished by heat conduction to the coldplate. The unit is conformal coated and the case is gasket sealed.

The final electrical design, list of materials, and mechanical configuration of the EMIU104D Static Inverter are presented in Appendix I.

Waveform photographs obtained during the performance tests conducted on the breadboard model of the Static Inverter and Acceptance Test Record Forms are presented in Appendix II.

FINAL DESIGN

The schematic, outline, and final assembly drawings of Engineered Magnetics Model EMIU104D Static Inverter are presented in Appendix I.

A. Electrical Design.

The Static Inverter operates with an input voltage of 50 to 60 VDC (56 VDC rated) and maintains a quasi-square wave, 400 Hz AC peak output voltage at a level two volts lower than the DC input voltage. The inverter circuits shown on Schematic Drawing 513634 consist of the following basic sections.

1. RFI Filter.

   Capacitors C26 and C27, and chokes L1 and L3 are connected to form a low-pass filter in each DC input line. The common point of the capacitors is connected to system neutral to provide low RF impedance to system neutral.

2. Audio Filter.

   The balanced low-pass audio filter circuit consists of coils A and B of choke L2, and capacitors C10A and C10B. The audio filter has a cut-off frequency of approximately 150 Hz and functions to reduce inverter induced noise on the DC bus and to reduce any ripples or modulations that may appear on the DC bus.

3. Low Level Series Regulator.

   The voltage supplied to the oscillator is regulated by the low level series regulator which also functions as an overcurrent protection device.

   The voltage regulation circuit consists of diodes CR6 and CR7, transistors Q10 through Q12, capacitors C9A through C9D, and resistors R32 through R37 and R94. The regulation circuit functions as follows: Q11, the control or pass element, and Q10 are connected as a high gain Darlington amplifier. CR6 is a voltage reference diode to which current is supplied from the regulator output through R33, to form a very stable reference. Resistors R35 through R37 are connected as a resistance divider for sensing the regulator output voltage. Any error signal is applied to correction amplifier Q12 and compared to the voltage reference. The difference in the signals is amplified by Q12 and supplied to Q10. Output filter capacitors C9A through C9D are connected in a series-parallel combination for purposes of redundancy. Diode CR7 functions for overall temperature correction of the regulator. Resistors R89, R90, and R96 form a path for transistor leakage current. Drive power for Q11 is supplied through resistor R94. The Darlington circuit transistors Q10 and Q11 are protected from being overdriven by R32 which functions as a current limiting resistor.

The pulse turn on and turn off circuits are made up of transistors Q8 and Q9, transformers T1 and T2, diodes CR32 and CR33, resistors R23, R27, R28, R88, R90, R91 and R92, and capacitors C2, C3, C6, and C7. Initial conditions of applying the DC bus with no turn on pulse are as follows: Q9 is turned on through the R27 and C7 time constant. (R27 and C7 are faster operating than R28 and C6). With Q9 saturated or turned on, the common point of R28 and R91 is almost at ground thereby holding Q8 off and the voltage regulator off. When Q8 is off, a DC signal is applied to the ripple regulator through R97, holding this circuit off also.

When a turn on pulse is applied to the input winding of transformer T2 (terminals 1 and 2) through DC blocking capacitor C3, the pulse is transformed to output winding terminals 3 and 4, rectified by CR33 and applied across R92. This voltage drives the emitter of Q9 more positive than its base, therefore turning Q9 off. As Q9 is going off, the common point of R28 and R91 is changing from ground to positive, turning on Q8 and the voltage regulator circuits. Q8 is now ready for the turn off pulse that is applied to winding 1 and 2 of T1, which reverses the turn on procedure.

If the AC output current increases to a level above a preset point (approximately 19 amperes RMS) for a period exceeding five seconds, a signal is applied through CR31 from the overcurrent circuit to R88 which turns off the regulator in the same manner that a signal to the input terminals of T1 turns off the regulator.

4. Ripple Regulator. (U.S. Pat. No. 3,368,139 assigned to Gulton Industries)

The ripple regulator is divided into four sub-circuits:

Pass element and drive circuits.

Filter section.

Voltage sense, reference and comparison.

Load current demand circuits.

The pass elements and drive circuits of the ripple regulator consists of Q1 through Q5, R1 through R4, R8, R9, R93, and R98. Q1 through Q3 form a compound Darlington amplifier with a forward bias supply from ØA driver supplying +2.5 VDC between points Z and Z'. Q4 and Q5 form a Schmitt trigger. As the regulator output voltage increases above a preset point, Q5 is turned on thereby turning off transistors Q1 through Q4. As the output voltage decreases past the preset point, Q5 switches off allowing Q1 through Q4 to switch on. This regulator operates in a switching mode and by careful selection of component parts high efficiency is obtained.

The filter section consists of L4, C8A, C8B, and CR1. When the voltage is low, Q1 is on passing current to charge L4. When the output voltage exceeds the preset point, Q1 switches off. L4 discharges its energy through the path of the load and CR1. When the voltage is reduced below the preset point, Q1 switches on therefore restarting the charge-discharge cycle.

The output voltage sense circuit consists of Q7, Q52 CR5, R22, R24 through R26, and R29 through R31. This circuit forms a differential amplifier. Q7, CR5, R22, and R25 form an emitter follower that holds a constant voltage across R25. This voltage is equal to Zener diode CR5 voltage less V_{BE} of Q7. R29A, R29B, R30 form a resistance divider that senses the output voltage. As this voltage increases past R25 voltage, Q52 is driven further into saturation thereby supplying drive to turn Q5 on and Q1 through Q4 off. When the input voltage is reduced below R25 voltage, Q52 is driven further out of saturation and reverses the mode of operation. R24 and R25 are current limiting resistors. R31 is a set-in-test resistor and used for initial factory calibration of the regulator.

The load current demand circuit is made up of the following components: Q6, Q51, CR3, CR4, C4, C5, C32, R7, and R12 through R21. Q6 and Q51 form a differential amplifier. As the load current that passes through R7 increases, there is also a voltage increase across R7. This voltage is applied to the base of Q51 through the parallel combination of R15 and R16. (R16 is a set-in-test resistor that is set only during initial calibration). This voltage signal then biases Q51 off thereby reducing the voltage across the common emitter resistor R19 as the base of Q6 is held at a fixed point by Zener diode CR4 and voltage divider R13 and R20. This reduction in emitter voltage biases Q6 further on and results in more collector current flow, which in turn increases the voltage drop across R18 and R21. R21 is connected in series with Zener diode reference CR5 in the voltage sense and control circuit. The increased voltage drop forces the voltage regulator to regulate at a higher output voltage...normally 40 volts at running load to 45 volts at starting load. The increased regulator voltage goes to the driver stages where it is supplied as higher base drive power for the output stages during the period that high output current is required. CR3 is used for temperature compensation. R12 and R17 are current limiting resistors. C4, C5, and C32 function as AC bypass capacitors.

5. Oscillator.

The oscillator section consists of the ØA, ØB, and ØC stages. The basic generation of the 400 Hz frequency is accomplished in the ØA oscillator. The ØA oscillator stage is made up of T3, Q13, Q14, C12 through C14, CR8, CR9, R38, R40, and L5.

L5 is a precision inductor and is combined with C14, a stable polycarbonate capacitor, to form a series resonant circuit. The oscillations started at turn-on by R38, C13, R40 and C12, are amplified by transistors Q13 and Q14, and sustained by regenerative feedback through windings 4 and 5 of transformer T3.

Diodes CR8 and CR9 provide reverse bias to hold the non-conducting transistor off while the other transistor is on during the half cycle. As an example, assume that transistor Q13 is turned on. Current flowing in the series resonant circuit provides base drive through Q13 emitter-base diode and through CR9 in a forward direction. The voltage drop across CR9 is approximately 0.7 volt and is of such a polarity as to hold Q14 off. The diode voltage drop will maintain Q14 at the off condition until the resonant circuit current reverses direction. At this time, Q14 will start to conduct and the polarity across CR8 will hold Q13 in the nonconducting state. T3 windings 6-7 and 8-9 supply base drive for the ØA driver stage. Winding 10-11 supplies a synchronizing signal to ØC oscillator stage. Windings 12-13-14 and diodes CR10, CR11, and C16 form a full wave DC rectifier circuit which supplies a bias voltage to the overcurrent time protection circuit. Winding 15 and 16 supplies the 400 Hz squarewave AC instrumentation frequency signal.

Since the circuits for ØB and ØC oscillators are identical, only one will be described. ØC is synchronized to ØA; ØB is synchronized to ØC.

The ØC oscillator is a free-running, magnetic multivibrator that is synchronized to the ØA oscillator.

Transformer T5 windings 1-2-3 are the primary for ØC. Windings 1 and 3 are connected to individual transistor collectors. The regulated DC power is supplied between winding 2 and the common transistor emitters. Initial oscillation is started by a bias resistor (R50) connected from transistor Q21 collector to the base of transistor Q22. Once oscillation is started it is self-driven or regenerative by transformer windings 4-5-6. In the basic multivibrator, the transformer core must be saturated in order to switch conduction to the second transistor. The ØC oscillator uses the synchronizing winding, T3-10 and 11, and saturable reactor L6 to switch conduction prior to saturation of the core, thus controlling the oscillator frequency. The saturable reactor reaches saturation after a time equivalent to 120^{o} of the 400 Hz signal. The applied voltage then appears across the base drive resistors in the proper polarity to switch conduction to the second transistor. On the second half of the 400 Hz signal from the synchronizing winding, the saturable reactor is forced to the other side of its hysteresis curve towards saturation in the reverse direction. After a time equivalent to 120^{o} the reactor reaches saturation and the signal across the base drive resistors switches conduction from the second transistor back to the first transistor. In this manner, ØC oscillator is slaved to the ØA oscillator and delayed 240^{o} with respect to it.

6. Driver Section.

Since all three phases of the driver section are identical, only one phase will be described. The ØA driver consists of T6, Q15, Q16, R41, and R42. These components are connected to form a push-pull power amplifier. The regulated DC voltage is supplied between T6-2 and the common emitter point. With no drive signal from ØA oscillator, Q15 or Q16 will not switch and no voltage can be transformed to the T6 secondary windings 4 through 19.

When windings T3-6 and 8 are positive to T3-7 and 9, Q15 will conduct. Base drive current is limited by R41 for Q15 and by R42 for Q16. During the half cycle that Q15 is conducting, Q16 is biased off and power is transformed to all secondary windings. The next half cycle, when the T3 winding has reversed polarity, Q15 is driven off and Q16 is on.

7. Output Power Section.

The output power stage is a three-phase full wave bridge connection. For ease of describing this circuit, the parallel components will not be considered. Since the individual phase stages are identical, only the ØA will be described.

The output power section is made up of transistors Q28 and Q29, base drive resistors R55 and R56, reverse current diodes CR12 through CR15, choke L11A and diodes CR36 and CR37. Power transistors Q28 and Q29 obtain base drive from windings T6-8 and 9, and T6-13 and 12 respectively on the drive transformers. The polarities applied to the base-to-emitter junctions drive one transistor into conduction while its series mate is driven into cut-off during one half cycle and then the polarities switch the transistors into a reverse condition during the other half cycle. Therefore, the ØA lead is alternately connected to positive and negative input leads through a power transistor. The reverse current diodes are connected across the collector-to-emitter of each power transistor. These diodes provide a path for the kickback current from the motor load. Choke L11A is connected in series with the DC bus and appears for approximately 10 microseconds as a high impedance to the DC current. This time duration allows for the worst case switching times of the power transistors (the differences in turn on vs turn off times). Diodes CR36 and CR37 form a redundant discharge path for L11A during the time period that it is not at high impedance.

The individual transistor emitter-collector voltage waveforms are squarewave, but the voltage across any two phases combine to form a quasi-square waveform as required by the Pesco Products Specification.

8. Voltage Sense Signal.

For instrumentation requirements there are two DC signals that are proportional to the rms output voltages for phases AB and CA. The ØAB circuit consists of T9, CR24, CR25, L9, C18, R76 and R77. Components for ØCA are T11, CR29, CR30, L10, C22, R86 and R87.

Transformer T9 provides isolation and voltage step-down. Diodes CR24 and CR25 with T9 windings 3-4-5 form a full wave, center tap rectifier circuit. L9 and C18 form a low pass filter section that supplies a well filtered DC voltage to the instrumentation output. R76 and R77 are factory calibration resistors.

9. Overcurrent Time Protection.

This circuit performs the function which turns off the inverter in the event of a locked motor rotor, if such condition lasts five seconds or longer. By reapplying the turn on pulse, the inverter will come back on, but will again turn itself off if the locked rotor condition still exists.

The overcurrent time protection circuit for ØA contains the following components with supply bias voltage from the ØA oscillator: Q49, Q50, CR26 through CR28, CR31, R78 through R85, C20 and C21.

The ØB current sensing circuit and ØA current sensing circuit are identical, therefore the ØB sensing circuit will not be discussed separately. Q49 is a unijunction transistor, R78 is a current limiting resistor, R79 through R81 and C20 form a pulse timer circuit. The RC time constant is formed by resistors R79 through R81 and capacitor C20. (The resistors are for factory calibration purposes). As C20 charges through the R at 5 ± 1 seconds, the voltage across this capacitor will reach the unijunction trigger voltage.

At this trigger voltage point a positive pulse is applied through CR31 to the low level series regulator which starts the inverter turn off conditions. To have this function based on a condition of overcurrent, the following circuit was used...Q50, R82, and R83. Q50 is connected emitter-collector across C20. R82 and R83 are connected as a voltage divider across the bias voltage and are of such values that cause Q50 to be full on or saturated, shorting out C20. T10A windings 4 and 5 sense the ØA output current. This signal is amplified by the turns ratio of T10 secondary winding 1-2-3 and then applied to the full wave rectifier circuit CR27 and CR28. The resulting DC signal is filtered by C21 and loaded by factory calibrated resistors R84 and R85. Below the overcurrent trip point of approximately 19 amperes rms, the DC voltage is less than the Zener voltage of CR26 and thereby is blocked from turning Q50 off and does not allow C20 to start its five second timing. At 19 amperes or greater, the DC signal has sufficient amplitude to exceed the Zener voltage of CR26 and is applied directly to the base of Q50 with the polarity required to turn off Q50 and thereby start the five second count before turn off.

B. Mechanical Design.

Packaging of the EMIU104D Static Inverter is shown on the drawings in Appendix I. The inverter design is based on conventional techniques which have been used successfully on many other space programs. Special design considerations were necessary in the areas affected by long term orbital mission requirements of the Brayton Power Conversion System.

Efficient heat transfer methods were necessary to assure moderate temperatures, long life, and reliable operation of the internal electrical components. This objective was achieved by designing an internal configuration that provides direct heat conduction paths to the inverter baseplate. The baseplate bolt pattern as shown on Figure 1, is closely spaced and the smooth machined surfaces of the baseplate assure intimate contact with the systems coldplate.

Features of structural rigidity and the ability to withstand dynamic loads were also obtained as a result of the thermal design consideration. Large cross-sectional areas which function to minimize thermal resistances resulted in overdesign from a strength standpoint.

The non-metallic materials for electrical insulation, potting and coating were selected on the basis of physical stability and prolonged life in a hard vacuum for extended periods.

Protection from earth associated contaminants such as moisture or sand and dust is provided by gasket-sealing the cover to the unit.

C. Thermal Analysis.

The thermal map of the Static Inverter was obtained as follows:

Assume that the thermal network of the Inverter is as shown on Figure 2. Also assume that all boundary temperatures (t_o) are equal, where o is the isothermal coldplate temperature. With these assumptions established the thermal resistance calculations are performed as follows:

$$R_{1b,o} = \frac{1}{hA} = \frac{1}{(100)(4)} \times (3.41)(144)\left(\frac{5}{9}\right) = .68^{\circ}\text{C/WATT}$$

$$R_{1a,o} = R_{1b,o} = .68^{\circ}\text{C/W}$$

$$R_{1,o} = \frac{4}{24} \times .68 = .113^{\circ}\text{C/W}$$

$$R_{3,o} = \frac{4}{33} \times .68 = .082^{\circ}\text{C/W}$$

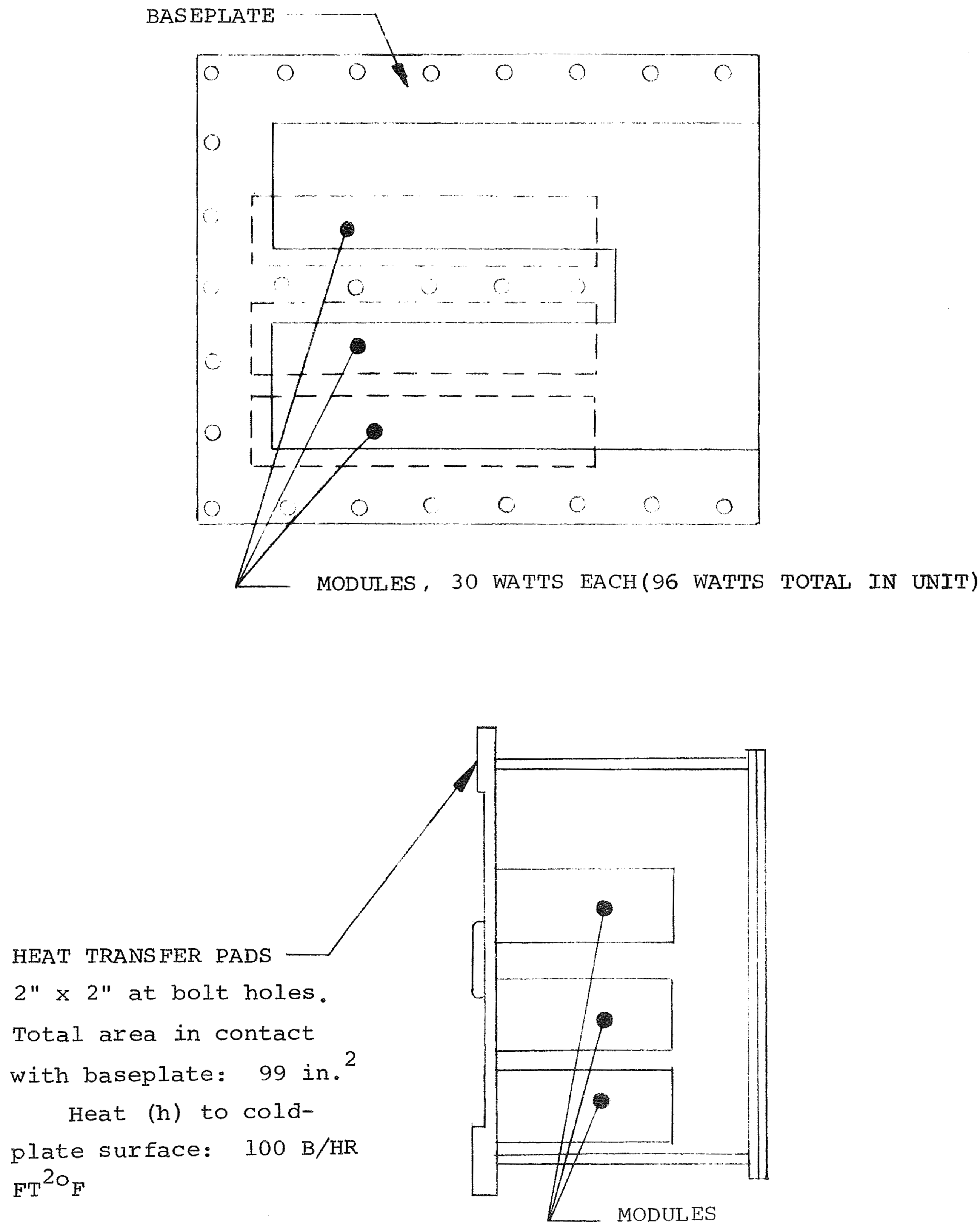


FIGURE 1. EMIU104D BASEPLATE CONFIGURATION

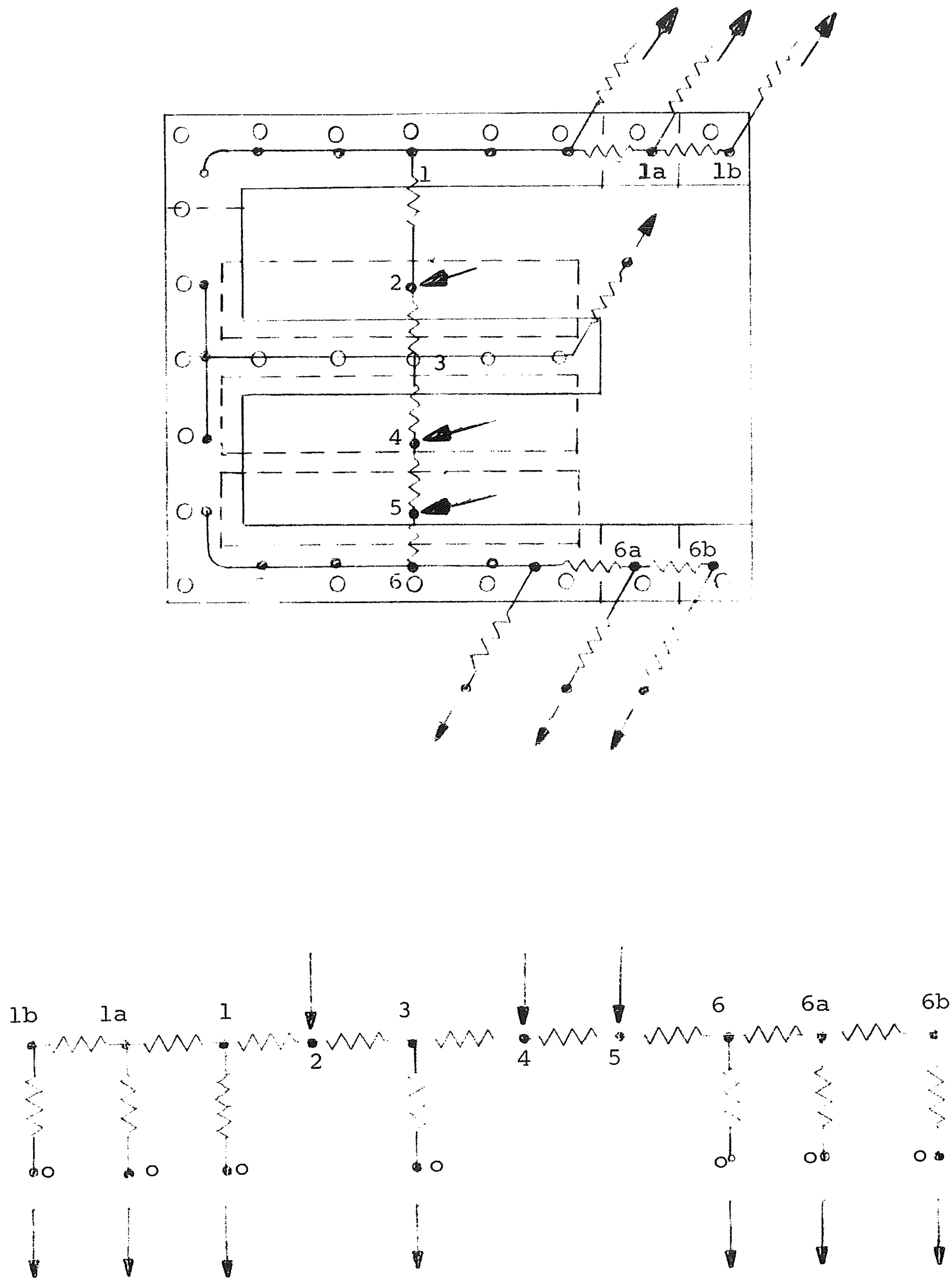


FIGURE 2. ASSUMED THERMAL NETWORK.

$$R_{6,o} = \frac{4}{26} \times .68 = .105^{\circ}C/W$$

$$R_{1b,1a} = \frac{1}{kA} = \frac{2}{(4.3)(2x.25)} = .93^{\circ}C/W$$

$$R_{1,1a} = R_{6,6a} = R_{6a,6b} = R_{1b,1a} = .93^{\circ}C/W$$

$$R_{1,2} = \frac{2.625}{(4.3)(9.5x.2)} + \frac{1}{(4.3)(9.5x.25)} = .419^{\circ}C/W$$

$$R_{2,3} = \frac{.875}{(4.3)(9.5x.2)} = \frac{1}{(4.3)(9.5x.25)} = .205^{\circ}C/W$$

$$R_{3,4} = R_{2,3} = .205^{\circ} C/W$$

$$R_{4,5} = \frac{2.188}{(4.3)(9.5 \times .2)} = .268^{\circ} C/W$$

$$R_{5,6} = \frac{.438}{(4.3)(9.5 \times .2)} + \frac{1}{(4.3(9.5 \times .25)} = .152^{\circ} C/W$$

To obtain the equivalent resistance of $R_{1a,\ 1}$; $R_{1,o}$;

$R_{1a,o}$; $R_{1b,1a}$; and $R_{1b,o}$ the following procedure is used.

$$R\left\{1a,o + 1b,1a + 1b,o\right\} = \frac{(R_{1a,1b} + R_{1b,o})(R_{1a,o})}{R_{1a,1b} + R_{1b,o} + R_{1a,o}}$$

$$= \frac{(.93 + .68)(.68)}{.93 + .68 + .68} = .478^{\circ}C/W$$

$$R\left\{1,1a + 1,o + .478\right\} = \frac{(.93 + .478)(.113)}{.93 + .478 + .113} = .104^{\circ}C/W$$

Equivalent $R_{2,1,o} = .419 + .104 = .523^{\circ} C/W$

The equivalent resistance of $R_{6,\ 6a}$; $R_{6a,6b}$; $R_{6,o}$; $R_{6a,o}$;

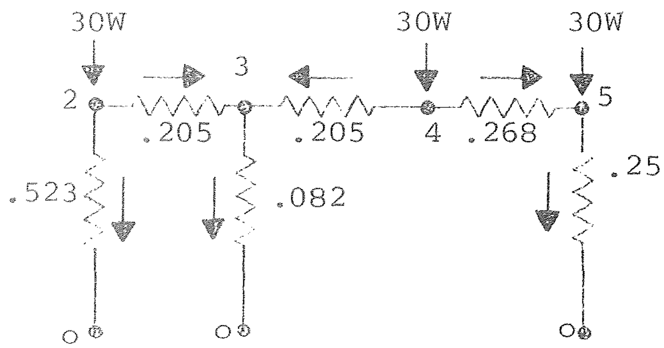
and $R_{6b,o}$ is

$$R\left\{6b,o + 6a,6b,6a,o\right\} = \frac{(.93 + .68)(.68)}{.93 + .68 + .68} = .478^{\circ} C/W$$

$$R\left\{6,6a + 6,o + .478\right\} = \frac{(.93 + .478)(.105)}{.93 + .478 + .105} = .098^{\circ} C/W$$

Equivalent $R_{5,6,o} = .152 + .098 = .25^{\circ}$ C/W

The equivalent network is



(q = heat load from inverter; BTU/HR)

1) $.523q_{2,o} = .205q_{2,3} + .082q_{3,o}$

2) $.205q_{4,3} + .082q_{3,o} = .268q_{4,5} + .25q_{5,o}$

3) $q_{2,o} + q_{2,3} = 30$

4) $q_{3',o} = q_{2,3} + q_{4,3}$

5) $q_{4,3} + Q_{4,5} = 30$

6) $q_{5,o} = 30 + q_{4,5}$

7) $q_{2,o} + q_{3,o} + q_{5,o} = 90$

1) and3) = $.523q_{2,o} = .205\ (30-q_{2,o}) + .082q_{3,o}$

$$.523q_{2,o} = 6.15 - .205q_{2,o} + .082q_{3,o}$$

$$.728q_{2,o} = 6.15 + .082q_{3,o}$$

2) and 5) $.205\ (30 - q_{4,5}) + .082q_{3,o} = .268q_{4,5} + .25q_{5,o}$

$$6.15 - .205q_{4,5} + .082q_{3,o} = .268q_{4,5} + .25q_{5,o}$$

$$6.15 - .743q_{4,5} + .082q_{3,o} = .25q_{5,o}$$

2),5) and 6) $6.15 - .473\ (q_{5,o} - 30) + .082q_{3,o} = .25q_{5,o}$

$6.15 - .473q_{5,o} + 14.19 + .082q_{3,o} = .25q_{5,o}$

$.082q_{3,o} + 20.34 = .723q_{5,o}$

1),3)and 7) $.728\ (90-q_{3,o} - q_{5,o}) = 6.15 + .082q_{3,o}$

$65.52 - .728q_{3,o} - .728q_{5,o} = 6.15 + .082q_{3,o}$

$59.37 - .81q_{3,o} = .728q_{5,o}$

$q_{5,o} = 81.5 - 1.11q_{3,o}$

2),5), 6) and 1),3),7) $.082q_{3,o} + 20.34 = .723\ (81.5 - 1.11q_{3,o}$

$.082q_{3,o} + 20.34 = 59 - .805q_{3,o}$

$q_{3,o} = \dfrac{59 - 20.34}{.082 + .805} = 43.6$ WATTS

$q_{5,o} = 81.5 - 1.11(43.6) = 33$ WATTS

$q_{2,o} = 90 - 43.6 - 33 = 13.4$ WATTS

Set $t_o = 0$

$$t_2 = R_{2,o}q_{2,o} = (.523)(13.4) = 7^{\circ}C$$

$$t_3 = R_{3,o}q_{3,o} = (.082)(43.6) = 3.58^{\circ}C$$

$$t_4 = t_3 + q_{4,3}R_{4,3} = 3.58 + (27)(.205) = 9.13^{\circ}C$$

$$t_5 = R_{5,o}q'_{5,o} = (.25)(33) = 8.25^{\circ}C$$

Referring back to the assumed thermal network diagram

$$t_1 = t_2 - R_{2,1}q_{2,1} = 7 - (.419)(13.4) = 1.4^{\circ}C$$

$$q_{1,o} = \frac{t_1}{R_{1,o}} = \frac{1.4}{.113} = 12.4 \text{ WATTS}$$

$$q_{1,1a} = 13.4 - 12.4 = 1 \text{ WATT}$$

$$t_{1a} = t_1 - R_{1,1a}q_{1,1a} = 1.4 - (.93)(1) = .47^{\circ}C$$

$$q_{1a,o} = \frac{t_{1a}}{R_{1a,o}} = \frac{.47}{.68} = .69 \text{ WATTS}$$

$$q_{1a,1b} = 1 - .69 = .31 \text{ WATTS}$$

$$t_{1b} = t_{1a} - R_{1a,1b}q_{1a,1b} = .47 - (.93)(.31) = .18^{\circ}C$$

$$t_6 = t_5 - R_{5,6}q_{5,6} = 8.25 - (.152)(33) = 3.23^{\circ}C$$

$$q_{6,o} = \frac{t_6}{R_{6,o}} = \frac{3.23}{.105} = 30.8 \text{ WATTS}$$

$$q_{6,6a} = 33 - 30.8 = 2.2 \text{ WATTS}$$

$$t_{6a} = t_6 - R_{6,6a}q_{6,6a} = 3.23 - (.93)(2.2) = 1.18^{\circ}C$$

$$q_{6a,o} = \frac{t_{6a}}{R_{6a,o}} = \frac{1.18}{.68} = 1.74 \text{ WATTS}$$

$$q_{6a,6b} = 2.2 - 1.75 = .46 \text{ WATTS}$$

$$t_{6b} = t_{6a} - R_{6a,6b,}q_{6a,6b} = 1.18 - (.93)(.46) = .75^{\circ}C$$

Worst case t_o:

$$t_o = t_c + \frac{q}{hA}$$

Where:

t_o = Coldplate surface temperature ($^{\circ}F$)

t_c = Maximum coolant temperature ($^{\circ}F$)

q = Heat load from inverter (BTU/HR)

h = Conductance, coolant to coldplate surface (BTU/HR FT^2 $^{\circ}F$)

A = Coldplate surface area (FT^2)

(assume coolant heat transfer only in baseplate contact area)

$$t^{\circ} = 150 + \frac{(96)(3.41)(144)}{(300)\quad(99)}$$

$$= 150 + 16$$

$$= 151.6^{\circ}F$$

$$= 66.5^{\circ}C$$

Worst case baseplate temperatures:

$$t_1 = 66.5 + 1.4 = 67.9^{\circ}C$$

$$t_{1a} = 66.5 + .5 = 67^{\circ}C$$

$$t_{1b} = 66.5 + .2 = 66.7^{\circ}C$$

$$t_2 = 66.5 + 7 = 73.5^{\circ}C$$

$$t_3 = 66.5 + 3.6 = 70.1^{\circ}C$$

$$t_4 = 66.5 + 9.1 = 75.6^{\circ}C$$

$$t_5 = 66.5 + 8.2 = 74.7^{\circ}C$$

$$t_6 = 66.5 + 3.2 = 69.7^{\circ}C$$

$$t_{6a} = 66.5 + 1.2 = 67.7^{\circ}C$$

$$t_{6b} = 66.5 + .8 = 67.3^{\circ}C$$

The Static Inverter component part temperatures were calculated based on the following power dissipations (watts):

	WATTS
Power transistors : 1.79W each x 8 =	14.3
Base drive resistors: 1.125W each x 8 =	9
Choke reset diodes: 1W each x 2 =	2
Reverse current diodes: .5W each x 2 =	1
Transformer: 1W x 1 =	1
TOTAL Power Dissipation Per Module	27.3W

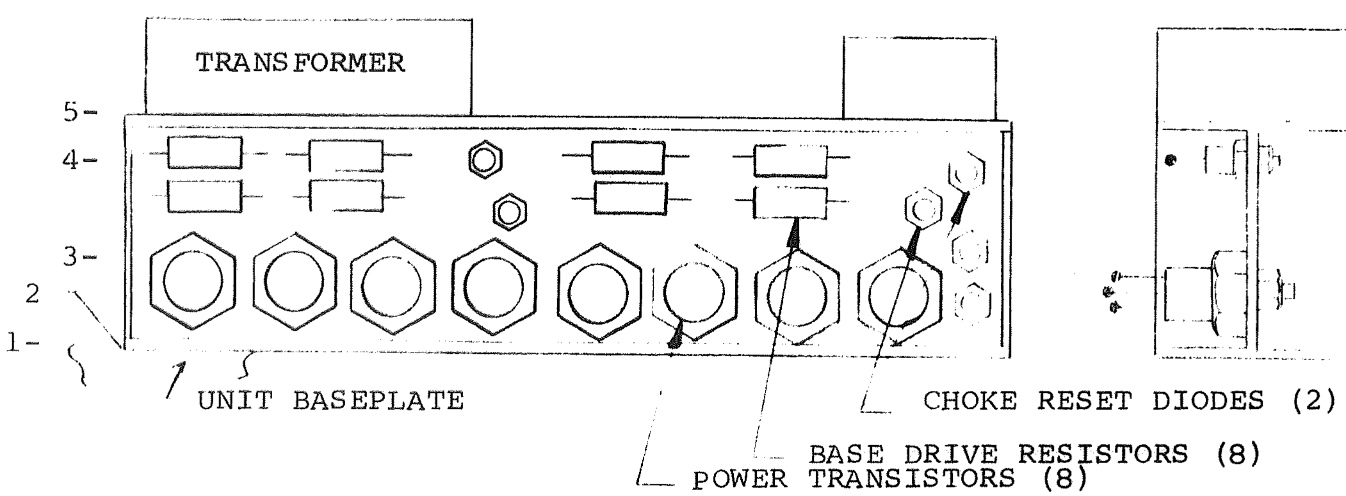
3 modules at 27.3W each = 82W

Miscellaneous losses = 8W

TOTAL POWER DISSIPATION = 90W

The above calculation is based on laboratory measurements of total power and calculated allocations for individual power dissipations. The baseplate thermal map calculations were based on previously obtained data which indicated a total load of 96 watts with 30 watts per module. The effect of this difference is negligible.

MODULAR CONFIGURATION



$t_1 = 75.6^{\circ}C$ (From baseplate thermal map for Phase B. Module.)

$t_2 = t_1 + \frac{q}{hA}$ (Temperature at bottom of module.)

q = 27.3 watts, total module dissipation

h = 50 BTU/HR FT^2 $^\circ$F, assumed joint conductance between module and baseplate

$$A = \frac{9.25 \times 2}{144} = .1285 \text{ FT}^2$$

$$t_2 = 75.6 + \frac{(27.3)\ (3.41)}{(50)\ \ (.1285)} \left(\frac{5}{9}\right)$$

$$= 75.6 + 8.05$$

$$= 83.65^\circ C$$

$$t_3 = t_2 + \frac{q\ell}{kA} \quad \text{(Temperature at transistor location)}$$

q = 27.3 WATTS

ℓ = .75 INCH

k = 4.3 WATTS/$^\circ$C

A = 9.25 x 125 = 1.158 IN^2

$$t_3 = 83.65 + \frac{(27.3)\ (.75}{(4.3)\ (1.158)}$$

$$= 83.65 + 4.11$$

$$= 87.76^\circ C$$

Transistor Case Temperature (t_c):

$$t_c = t_3 + qR$$

q = 1.79 WATTS

R = 2°C/W (Assumed value for dry mica insulator)

$$t_c = 87.76 + (1.79)\ (2)$$

$$= 87.76 + 3.58$$

$$= 91.34^\circ C$$

(Manufacturer's recommended case temperature limit:

$175^{\circ}C - (.5^{\circ}C/W)(1.79W) \approx 174^{\circ}C$)

$91.34^{\circ}C$ case temperature is acceptable

$t_4 = t_3 \frac{q\ell}{kA}$ (Temperature at location of base drive resistors and choke reset diodes)

$q = 27.3-14.3 = 13$ WATTS

$l = 1$ INCH

$k = 4.3$ WATTS/IN$^{\circ}$C

$A = 9.25 \times 1.25 = 1.158$ IN^2

$$t_4 = 87.76 + \frac{(13)(1)}{(4.3)(1.158)}$$

$$= 87.76 + 2.61$$

$$= 90.37^{\circ}C$$

Diode Case Temperature (t_d):

$$t_d = t_4 + qR$$

$q = 1$ WATT

$R = 3^{\circ}C/W$ (Assumed value for dry mica insulator)

$$t_d = 90.37 + (1)(3)$$

$$= 93.37^{\circ}C$$

(Manufacturer's recommended case temperature limit:

$200^{\circ}C - (2^{\circ}C/W)(1W) = 198^{\circ}C$)

$93.37^{\circ}C$ case temperature is acceptable.

Base Drive Resistor Temperature (t_R):

$$t_R = t_4 + qR$$

$q = 1.125$ WATTS

$$R = \underbrace{\frac{(6^{\circ}C\,IN^2/W)}{(.75IN^2)}}_{\substack{\text{Interface,}\\ \text{module to}\\ \text{terminal board}}} + \underbrace{\frac{(\,.08IN)}{(.00528W/IN^{\circ}C)(.3IN^2)}}_{\substack{\text{Conduction thru epoxy terminal board}\\ \text{epoxy fillet to resistor}}} = 8 + 50 = 58^{\circ}C/W$$

$$t_R = 90.37 + (1.125)(58)$$

$$= 90.37 + 65.25$$

$$= 155.62^{\circ}C$$

(Manufacturer's recommended case temperature limit = $275^{\circ}C$)

$\therefore 155.62^{\circ}C$ is acceptable.

$$t_5 = t_4 + \frac{ql}{kA} \quad \text{(Temperature at top surface of module)}$$

$q = 1$ WATT

$l = .75$ INCH

$k = 4.3$ WATTS/$IN^{\circ}C$

$A = 9.25 \times 125 = 1.158\ IN^2$

$$t_5 = 90.37 + \frac{(1)(.75)}{(4.3)(1.158)}$$

$$= 90.37 + .15$$

$$= 90.52^{\circ}C$$

Transformer Temperature (t_r)

$$t_r = t_5 + qR$$

$$q = 1 \text{ WATT}$$

$$R = \underbrace{\frac{(6^{\circ}CIN^2/W)}{(6IN^2)}}_{\substack{\text{Interface:}\\ \text{module to}\\ \text{transformer cup}}} + \underbrace{\frac{(.1IN)}{(.00528W/IN^{2\circ}C)(6IN^2)}}_{\substack{\text{Conduction thru epoxy}\\ \text{cup and potting mat'l}}}$$

$$= 1^{\circ}C/W + 3.15^{\circ}C/W = 4.15^{\circ}C/W$$

$$t_r = 90.52 + (1)(4.15)$$

$$= 94.67^{\circ}C$$

Transformer temperature limit $105^{\circ}C$ continuous

$94.67^{\circ}C$ short term (2 hours max) is acceptable.

SUMMARY OF THERMAL ANALYSIS

COMPONENT	ACTUAL TEMPERATURE ($^{\circ}C$)	RATED TEMPERATURE ($^{\circ}C$)
POWER TRANSISTOR	91.34	174
BASE DRIVE RESISTOR	155.62	275
CHOKE RESET DIODES	93.37	198
TRANSFORMER	94.67	105

NOTE: The above calculated temperatures are based on worst case coolant temperature of 150°F. Since this condition will exist only intermittently for two hour periods, actual steady state temperatures will be lower.

D. Reliability

1. Reliability Estimate

This reliability estimate is based on the total electrical component parts count and utilizes component part failure rates and other estimating techniques as outlined in the Engineered Magnetics Reliability Handbook and MIL-HDBK-217A. This reliability estimates consists of two parts:

Part a: Based on H-version (high reliability)parts.

Part b: Based on U-version (ultra high reliability)parts.

Certain basic assmumptions were used in the preparation of this reliability estimate and are defined as follows:

a. No workmanship errors exist which can contribute to a system failure (special controls and procedures have been devised to eliminate this failure mode).
b. Failure of any part used in the calculations will constitute a system failure.
c. Ambient temperature is less than $40^{o}C$.
d. Redundant parts, as such, are not used in the system.
e. All component parts are used with proper deratings as per Engineered Magnetics' derating policy and Pesco Products derating policy.
f. Transformers will be considered as separate windings.

The MTBF (Mean Time Before Failure) can be calculated by summing the individual component part failure rates and then taking the reciprocal of this sum, i.e.,

$$MTBF = \frac{1}{\Sigma \lambda_i}$$

where λ_i = individual component part failure rate, which will be expressed in 10^{-8} failures/hour (bits).

Part a) For the H-version parts,

$$\text{MTBF} = \frac{1}{\Sigma \lambda i_H} = \frac{1}{4314.8 \times 10^{-8}} = 23{,}176 \text{ hours.}$$

Part b) For the U-version parts,

$$\text{MTBF} = \frac{1}{\Sigma \lambda i_U} = \frac{1}{1129.8 \times 10^{-8}} = 88{,}511 \text{ hours.}$$

Table I lists the H-version parts and their bit count, Table II similarly lists the U-version parts bit count.

PART NUMBER	QTY	FR	NFR	SYMBOL
CAPACITORS				
CSR13 (solid ta)	13	33.00	429.00	C1-5, C15,16,18, C20-22, C26-27
625B	3	9.00	27.00	C6,7,24
118P	6	1.60	9.60	C11,13,17,19,23
GI75576 (ta foil)	4	10.00	40.00	C8A, 10A, 10B, 8B
EM79474 (ta foil)	4	1.00	4.00	C9A, 9B, 9C, 9D
EM78381 (polycarb.)	1	6.80	6.80	C14
DIODES				
JAN 1N645	18	19.50	351.00	CR2, 3,7-11, 24,25, CR27-33, CR36, 37
JAN 1N645	18	28.00	504.00	CR12-23, CR38-43
GI79430H (6.6V Zener)	4	40.00	160.00	CR4, 5,6,26
EM74808H-1	1	28.00	38.00	CR1
EM76014-1H	2	30.00	60.00	CR34,35
TRANSISTORS AND UNIJUNCTIONS				
GI711347H	1	28.00	28.00	Q1
GI78324H	1	28.00	28.00	Q2
GI711477H	5	30.00	150.00	Q3,7,10,11,52
GI73531H-2	7	30.00	210.00	Q4-6,8,9,12,51

TABLE I. H-VERSION PARTS ESTIMATE

PART NUMBER	QTY	FR	NFR	SYMBOL
TRANSISTORS AND UNIJUNCTIONS	(CONT'D			
GI73531-120H	6	30.00	180.00	Q13,14,17,18,21,22
EM710438H-1	6	28.00	168.00	Q15,16,19,20,23,24
EM79807	24	28.00	672.00	Q25-48
GI74706H	1	14.00	14.00	Q50
EM74762H	1	30.00	30.00	Q49
RESISTORS				
RN55C	49	14.00	742.00	R3-6,8-11,13-20 R23-32,35-38,40 R45,50,78-85 R88-97, R84A-85A
RN60C	1	14.00	14.00	R34
RS2B	45	4.00	180.00	R1,2,12,21,22,39 R41-44,46-49,53-75, R76,77,86,87,94
WIRE (Resistance)	1	4.00	4.00	R7
MAGNETICS				
Chokes				
EM3XXXX (1 winding)	10	1.00	10.00	L1,3,4,5,8,9,10,11A, B,C
EM3XXXX (2 windings)	1	2.00	2.00	L2

TABLE I. H-VERSION PARTS ESTIMATE (CONT'D)

PART NUMBER	QTY	FR	NFR	SYMBOL
<u>MAGNETICS</u> (CONT'D				
<u>Saturable Reactors</u>	2	2.00	4.00	L1, L2
<u>Transformers</u>				
2 windings	2	2/wnd (4)	8.00	T1, T2
3 windings	4	2/wnd (6)	24.00	T9,10,11,10B
6 windings	1	2/wnd (12)	12.00	T3
7 windings	1	2/wnd (14)	14.00	T5
9 windings	1	2/wnd (18)	18.00	T4
10 windings	2	2/wnd (20	40.00	T7,T8
12 windings	1	2/wnd (24)	24.00	T6
<u>MISCELLANEOUS</u>				
Connectors	3	6.0	18.00	J1,2,3
Connections	1000	.1	100.00	------

$\Sigma \lambda_{i_H}$ = Total FR = 4314.80

TABLE I. H-VERSION PARTS ESTIMATE (CONT'D)

PART NUMBER	QTY	FR	NFR	SYMBOL
CAPACITORS				
CSR13	13	.30	3.9	C1-5,15,16,18, C20-22, C26-27
CYK (per 711411)	2	2.00	6.00	C6,7
CYFR (per 711468)	3	.60	1.80	C11,12,13
GI75576	4	10.00	40.00	C10,10A,8A,8B
EM79474	4	1.00	4.00	C9A,B,C,D
EM78381	5	5.00	25.00	C14,17,19,23,24
DIODES				
GI710456U	18	.20	3.60	CR2,3,7-11,24,25 CR27-33,CR36-37
JAN TX1N1202	18	3.00	54.00	CR12-23,CR38-43
GI79430U-1	4	4.00	16.00	CR4-6,26
EM74808U-1	1	3.00	3.00	CR1
EM76014-1U	2	4.00	8.00	CR34,35
TRANSISTORS AND UNIJUNCTIONS				
GI711347U	1	5.00	5.00	Q1
GI78324U	1	10.00	10.00	Q2
GI711477U	5	5.00	25.00	Q3,7,10,11,52
GI73531U-2	7	5.00	35.00	Q4-6,8,9,12,51
GI73531-120U	6	5.00	30.00	Q13,14,17,18,21,22

TABLE II. U-VERSION PARTS ESTIMATE

PART NUMBER	QTY	FR	NFR	SYMBOL
<u>TRANSISTORS AND UNIJUNCTIONS (CONT'D)</u>				
EM710438U-1	6	5.00	30.00	Q15,16,19,20, 23, 24
EM77684U	24	20.00	480.00	Q25-48
GI74706U	1	4.00	4.00	Q50
EM74762U	1	4.00	4.00	Q49
<u>RESISTORS</u>				
RNC55H	53	1.00	53.00	R3-6,8-11,13-20, R23-32,35-38,40, R45,50,78-85, 88-97,84A, 85A
RN60C	1	1.30	1.30	R34
AGS	40	.12	4.80	R1,2,21,39, 41-44, 46-49, 53-75,76, 86
ARS	4	.12	.48	R12,22,77,87
RS2B (20 KΩ)	1	4.00	4.00	R33
WIRE (Resistance)	1	2.00	2.00	R7
<u>MAGNETICS</u>				
<u>Chokes</u>				
EM3XXXX (1 winding)	10	1.00	10.00	L1,3-5,8,9
EM3XXXX (2 windings)	1	2.00	2.00	L2

TABLE II. U-VERSION PARTS ESTIMATE (CONT'D)

PART NUMBER	QTY	FR	NFR	SYMBOL
MAGNETICS (CONT'D)				
Saturable Reactors				
EM3XXXX	2	2.00	4.00	L6, L7
Transformers				
EMXXXXX				
2 windings	2	4.00	8.00	T1,2
3 windings	4	6.00	24.00	T9,10,11,10B
6 windings	1	12.00	12.00	T3
7 windings	1	14.00	14.00	T5
9 windings	1	18.00	18.00	T4
10 windings	2	20.00	40.00	T7,8
12 windings	1	24.00	24.00	T6
MISCELLANEOUS				
Connectors	3	6.00	18.00	J1,2,3
Connections	1000	.1	100.00	------

$$\Sigma \lambda_{i_U} = \text{Total FR} = 1129.48$$

TABLE II. U-VERSION PARTS ESTIMATE (CONT'D)

2. Failure Mode and Failure Effect Analysis

Failure Effect Analysis is a method of systematically examining the principal manner in which an article of equipment may fail. Engineered Magnetics has prepared a form for this purpose and lists the most conceivable failures together with their effect on the equipment and consequences to the performance of the equipment.

Under the column headed "System Failure" an explanation is given as to the system failure resulting from an assumed failure. "Degrading Failure" means the primary mission of the equipment is not effected by the assumed failure except for some degradation to the performance of the unit. "Catastrophic Failure" means the primary mission of the equipment will not be met by the assumed failure.

The Probability of Failure of each mode is entered in accordance with the following code:

20%	=	1 failure out of 5 possible failures.
10%	=	1 failure out of 10 possible failures.
5%	=	1 failure out of 20 possible failures.
1%	=	1 failure out of 100 possible failures.
.1%	=	1 failure out of 1,000 possible failures.
.01%	=	1 failure out of 10,000 possible failures.

These probabilities reference the likelihood of failures to the known failures of existing units of similar type(s) and are an estimate. For any one assumed failure the probability indicates the likelihood that the part being considered would fail. The highest probability is reserved for the power handling devices. Each row lists the effect of one part even though several parts, which have duplicate functions, are listed.

Since the predominent catastrophic mode of failure in a resistor is "open", the Failure Effect Analysis has not considered shorted resistors.

CUSTOMER NO. ____________

EM MODEL NO. EMIU104D

GULTON INDUSTRIES, INC.
Engineered Magnetics Division

FAILURE MODE AND FAILURE EFFECT ANALYSIS

AUDIO FILTER

ITEM	FAILURE MODE	SYSTEM EFFECT	SYMPTOMS AND LOCAL EFFECT INCLUDING DEPENDENT FAILURE	DETAIL EFFECT	PROBABILITY OF FAILURE/10^6 HOURS	REMARKS
L2A or L2B	open	C.F.	No input power to the inverter	Inverter will stay off	.2	
L2A or L2B	short	D.F.	Inverter will be more susceptable to input ripple (audio)	Increased induced ripple into DC buss line	.05	
C10A or C10B	open	D.F.	same as above	same as above	.1	

CUSTOMER NO. ______

EM MODEL NO. EMIU104D

GULTON INDUSTRIES, INC.
Engineered Magnetics Division

FAILURE MODE AND FAILURE EFFECT ANALYSIS

RFI FILTER SECTION

ITEM	FAILURE MODE	SYSTEM EFFECT	SYMPTOMS AND LOCAL EFFECT INCLUDING DEPENDENT FAILURE	DETAIL EFFECT	PROBABILITY OF FAILURE/10^6 HOURS	REMARKS
L1	open	C.F.	No input power to the ripple regulator and low level series regulator	Since oscillators + power amplifier will not receive any pwr. inverter will stay off	.02	
L1	short	D.F.	Inverter will produce more RFI noise into the DC buss	Ripple reflected back into the input line will increase	.1	
L3	open	C.F.	No input power to the ripple regulator and low level series regulator	Since oscillators + power amplifier will not receive any pwr. inverter will stay off	.02	
L3	short	D.F.	Inverter will produce more RFI noise into the DC buss	Ripple reflected back into the input line will increase	.1	
C26	open	D.F.	same as above	same as above	.05	
C26	short	D.F.	+50 VDC line will clear the shorted component	No output	.01	
C27	open	D.F.	Inverter will produce more RFI noise into the DC buss	Ripple reflected back into the input line will increase	.05	
C27	short	D.F.	same as above	same as above	.01	

CUSTOMER NO. ____________

EM MODEL NO. EMIU104D

GULTON INDUSTRIES, INC.
Engineered Magnetics Division

FAILURE MODE AND FAILURE EFFECT ANALYSIS

TURN ON AND TURN OFF CIRCUIT SERIES REGULATOR

ITEM	FAILURE MODE	SYSTEM EFFECT	SYMPTOMS AND LOCAL EFFECT INCLUDING DEPENDENT FAILURE	DETAIL EFFECT	PROBABILITY OF FAILURE/10^6 HOURS	REMARKS
R27	open	C.F. or D.F. depending on system	Q8 will turn on, turning on the ripple regulator + series voltage regulator	Turn off pulses have no effect on the inverter	.05	
R28	open	C.F.	Q9 will turn on, turning off the ripple regulator + and series voltage regulator	Turn on pulses have no effect on the inverter	.05	
R23	open	C.F.	Q8 will have no supply voltage, R97 will act as if open. Ripple regul. will be on but series regulator will be off	No output from the inverter	.05	
R91	open	C.F.	Q9 will have no supply voltage, Q8 and thereby ripple regulator will be off, series regul. will be on	No output from the inverter	.05	
R90	open	C.F.	Series regul. will be on, but Q8 and thereby ripple regulator will be off; turn on and turn off circuit will have no effect	No output from the inverter	.05	

CUSTOMER NO. ______

EM MODEL NO. EMIU104D

GULTON INDUSTRIES, INC.
Engineered Magnetics Division

FAILURE MODE AND FAILURE EFFECT ANALYSIS

TURN ON AND TURN OFF CIRCUIT SERIES REGULATOR

ITEM	FAILURE MODE	SYSTEM EFFECT	SYMPTOMS AND LOCAL EFFECT INCLUDING DEPENDENT FAILURE	DETAIL EFFECT	PROBABILITY OF FAILURE/10^6 HOURS	REMARKS
R89	open	C.F.	Q10 will always be off; by applying turn off pulse, ripple regulator will turn off but series regulator will stay on	Output of the invert. will be normal except during off state will drain more than normal (leakage) current	.05	
R96	open	C.F.	Q11 will always be off; by applying turn on pulse, ripple regulator will turn on but series regulator will stay off	No output from the inverter	.05	
R32	open	D.F.	Series regulator will not be able to regulate	Shift will change, but will have a tendency to be held by the motor		
R34	open	D.F.	same as above	same as above	.05	
R36 or R35 or R37	open	C.F.	Series voltage reg. will not be able to sense output voltage	same as above	.15	

CUSTOMER NO. ____________

EM MODEL NO. EMIU104D

GULTON INDUSTRIES, INC.
Engineered Magnetics Division

TURN ON AND TURN OFF
CIRCUIT SERIES REGULATOR

FAILURE MODE AND FAILURE EFFECT ANALYSIS

ITEM	FAILURE MODE	SYSTEM EFFECT	SYMPTOMS AND LOCAL EFFECT INCLUDING DEPENDENT FAILURE	DETAIL EFFECT	PROBABILITY OF FAILURE/10^6 HOURS	REMARKS
C6	open	depends on system	Q8 will turn on before Q9 turning on ripple regulat. and series voltage regulator	Turn on and turn off pulse will have no effect; inverter will start when DC bus voltage is applied	.05	
C6	short	C.F.	Base of Q8 will be grounded keeping it off at all times	Inverter will have no output since series regulator and ripple regulator will stay off	.02	
C7	open	C.F.	Q9 will turn on before Q8, keeping series and ripple regulator off	The inverter will have no output	.02	
C7	short	depends on system	Q9 will always stay off, it will turn on ripple + series regulator before applying turn on pulse	Turn on pulse will will have no effect on the inverter; turn off pulse will turn off the invert. but will turn back on after pulse is removed	.05	
C9A or C9B or C9C or C9D	open	D.F.	Increase ripple at the output of series regulator	Since output capacit. of the series regul. have built in redund. there will be no effect on the regul.	.4	

CUSTOMER NO. ________________

EM MODEL NO. EMIU104D

GULTON INDUSTRIES, INC.
Engineered Magnetics Division

TURN ON AND TURN OFF CIRCUIT SERIES REGULATOR

FAILURE MODE AND FAILURE EFFECT ANALYSIS

ITEM	FAILURE MODE	SYSTEM EFFECT	SYMPTOMS AND LOCAL EFFECT INCLUDING DEPENDENT FAILURE	DETAIL EFFECT	PROBABILITY OF FAILURE/10^6 HOURS	REMARKS
CR32	open	depending on system D.F.	Turn off pulse will be missing to the series regulator	Turn off pulse will not turn off the inverter	.02	
CR32	short	C.F.	Secondary of T1 will saturate	same as above	.05	
CR33	open	C.F.	Turn on pulse will be missing to the series regulator	Turn on pulse will not turn on the inverter	.02	
CR33	short	C.F.	Secondary of T2 will saturate	same as above	.05	
CR31	open	D.F.	Pulse from the overcurrent time protection circuit to the series regulat. will be missing	Overcurrent time protection circuit will not turn off the inverter even after the trip point is reached at phase B or C	.02	
CR31	short	C.F.	Time protection erratic	Time protection erratic	.05	
CR7	open	depending on system	Series regulator will not be able to regulate	Shift in the output phase	.02	
CR7	short	D.F.	Change in the regulation voltage of the series regulat.	Shift in the output phase	.05	

CUSTOMER NO. ____________

EM MODEL NO. EMIU104D

GULTON INDUSTRIES, INC.
Engineered Magnetics Division

FAILURE MODE AND FAILURE EFFECT ANALYSIS

TURN ON AND TURN OFF CIRCUIT SERIES REGULATOR

ITEM	FAILURE MODE	SYSTEM EFFECT	SYMPTOMS AND LOCAL EFFECT INCLUDING DEPENDENT FAILURE	DETAIL EFFECT	PROBABILITY OF FAILURE/10^6 HOURS	REMARKS
C9A or C9B or C9C or C9D	short	D.F.	Decreased ripple	Since outout cap. of the series reg. have built in redundancy, there will be no effect on the regulator	.1	
C2	open	depending on system	Turn off pulse will have no effect on the series regul.	Turn off pulse will be unable to turn off the inverter since turn off pulse will be missing to the series regulator		
C2	short	C.F.	Turn off pulse will saturate the primary of T1	same as above	.002	
C3	open	C.F.	Turn on pulse will have no effect on the series regulat.	Turn on pulse will be unable to turn on the inverter since turn on pulse will be missing to the series regulator	.1	
C3	short	C.F.	Turn on pulse will saturate the primary of T2	same as above	.02	

CUSTOMER NO. ____________

EM MODEL NO. EMIU104D

GULTON INDUSTRIES, INC.
Engineered Magnetics Division

TURN ON AND TURN OFF
CIRCUIT SERIES REGULATOR

FAILURE MODE AND FAILURE EFFECT ANALYSIS

ITEM	FAILURE MODE	SYSTEM EFFECT	SYMPTOMS AND LOCAL EFFECT INCLUDING DEPENDENT FAILURE	DETAIL EFFECT	PROBABILITY OF FAILURE/10^6 HOURS	REMARKS
Q8	short	depending on system D.F.	Ripple regulator will always stay on	Turn off or turn on pulse will have no effect on the invert.	.1	
Q8	open	C.F.	Ripple regulator will always stay off	No output from the inverter	.1	
Q9	short	C.F.	same as above	same as above	.1	
Q9	open	depending on system D.F.	Ripple regulator + series regulator will always stay on	Turn on or turn off pulse will have no effect on the invert.	.1	
Q10	short	C.F.	Series regulator will not work	No output from the inverter	.5	
Q10	open	depending on system	Series regulator will turn on before applying turn on pulse	Inverter will draw more than normal (leakage) current in the off state, change in the phase of the output	.5	
Q11	short	depending on system	Series regulator will not regulate, series regulator will not be able to turn off	Change in the output phase of the inverter	6	
Q11	open	depending	No regulated output from the series regulator	Change in the output phase, no other effect	2	

:USTOMER NO. ____________

:M MODEL NO. EMIU104D

GULTON INDUSTRIES, INC.
Engineered Magnetics Division

FAILURE MODE AND FAILURE EFFECT ANALYSIS

TURN ON AND TURN OFF CIRCUIT SERIES REGULATOR

ITEM	FAILURE MODE	SYSTEM EFFECT	SYMPTOMS AND LOCAL EFFECT INCLUDING DEPENDENT FAILURE	DETAIL EFFECT	PROBABILITY OF FAILURE/10^6 HOURS	REMARKS
Q12	open or short	depending on system	Series regulator will not be able to regulate	Change in the output phase inverter	.1	

CUSTOMER NO. ______________

EM MODEL NO. EMIU104D

GULTON INDUSTRIES, INC.
Engineered Magnetics Division

FAILURE MODE AND FAILURE EFFECT ANALYSIS

DRIVE STAGE

ITEM	FAILURE MODE	SYSTEM EFFECT	SYMPTOMS AND LOCAL EFFECT INCLUDING DEPENDENT FAILURE	DETAIL EFFECT	PROBABILITY OF FAILURE/10^6 HOURS	REMARKS
Q15 or 16 or 19 or 20 or 23 or 24	short	C.F.	+ 50 V shorted through transistor	Probably open up the winding of T6, T7, or T8, or open up the transistor. The remaining two phases will be operational, one of the voltage senses will not work	3.0	
Q15 or 16 or 19 or 20 or 23 or 24	open	C.F.	Phase A, B or C will not work	Two phases will be operational, one of the voltage senses will not work	12.0	
R41 or 42 or 46 or 47 or 51 or 52	open	C.F.	same as above	same as above	.3	
Secondary of T3(6,7) or T3(9,8) or T4(7,8)	open	C.F.	One of the phases of A, B, or C will not work	Two phases of the inverter will be operational; one of the voltage senses will not work	.6	
Secondary of T3(6,7) or T3(9,8) or T4(7,8)	short	C.F.	Oscillators will not work	No output at any of the phases	.4	

CUSTOMER NO. ____________

EM MODEL NO. EMIU104D

GULTON INDUSTRIES, INC.
Engineered Magnetics Division

FAILURE MODE AND FAILURE EFFECT ANALYSIS

DRIVE STAGE

ITEM	FAILURE MODE	SYSTEM EFFECT	SYMPTOMS AND LOCAL EFFECT INCLUDING DEPENDENT FAILURE	DETAIL EFFECT	PROBABILITY OF FAILURE/10^6 HOURS	REMARKS
Primary of T6(1,2) or T6(2,3) or T7(1,2) or T7(2,3) or T8(1,2) or T8(2,3)	open	C.F.	One of the phases of A, B, or C will not work	Two phases of the inverter will be operational; one of the voltage senses will not work	.6	
Primary of T6(1,2) or T6(2,3) or T7(1,2) or T7(2,3) or T8(1,2) or T8(2,3)	short	C.F.	Drive stage will draw excessive current and probably open up the winding or transistor	same as above	.4	

CUSTOMER NO. ______________

EM MODEL NO. EMIU104D

GULTON INDUSTRIES, INC.
Engineered Magnetics Division

FAILURE MODE AND FAILURE EFFECT ANALYSIS FREQUENCY SENSE

ITEM	FAILURE MODE	SYSTEM EFFECT	SYMPTOMS AND LOCAL EFFECT INCLUDING DEPENDENT FAILURE	DETAIL EFFECT	PROBABILITY OF FAILURE/10^6 HOURS	REMARKS
R39	open	C.F.	Instrumentation failure	No output at the frequency sense points; no other effect	.05	
C11	open	D.F.	same as above	Frequency sense output will increase in amplitude	.05	
C11	short	C.F.	same as above	No output at the frequency sense points; no other effect		
T3(15,16)	Short	C.F.	Master oscillator will not work	No output from the inverter	.05	
T3(15,16)	Open	D.F.	Instrumentation failure	No output at the frequency sense points, no other effect	.1	

CUSTOMER NO.
EM MODEL NO. EMIU104D

GULTON INDUSTRIES, INC.
Engineered Magnetics Division

MASTER OSCILLATOR
PHASE A, B, AND C

FAILURE MODE AND FAILURE EFFECT ANALYSIS

ITEM	FAILURE MODE	SYSTEM EFFECT	SYMPTOMS AND LOCAL EFFECT INCLUDING DEPENDENT FAILURE	DETAIL EFFECT	PROBABILITY OF FAILURE/10^6 HOURS	REMARKS
R38 or 40	open	D.F.	Master oscillator switching effected	No effect on the inverter	.1	
C12 or 13	open	D.F.	same as above	same as above	.1	
C12 or 13	short	D.F.	same as above	same as above	.08	
C13 or 14	open	D.F.	Loss of master oscillator	No inverter output	.2	
Q13 or 14	short	D.F.	same as above	No inverter output	.1	
L5	open	C.F.	same as above	The inverter will stay off	.1	
L5	short	C.F.	same as above	same as above	.05	
C14	open	C.F.	same as above	same as above	.05	
T3(1,2)or T3(2,3)	open	C.F.	same as above	same as above	.2	
T3(1,2)or T3(2,3)	short	C.F.	same as above	same as above	.1	

CUSTOMER NO. ______

EM MODEL NO. EMIU104D

GULTON INDUSTRIES, INC.
Engineered Magnetics Division

FAILURE MODE AND FAILURE EFFECT ANALYSIS

ITEM	FAILURE MODE	SYSTEM EFFECT	SYMPTOMS AND LOCAL EFFECT INCLUDING DEPENDENT FAILURE	DETAIL EFFECT	PROBABILITY OF FAILURE/10^6 HOURS	REMARKS
R43, 44, 48 or 49	open	C.F.	Phase B or C oscil. will not work	Loss of B or C output phase	0.2	
R45 or R50	open	C.F.	Oscillator will not start	Loss of inverter	0.1	
L6 or L7	open	C.F.	Oscillator freq. will change as switching of the oscillator is done by saturable reactor prior to saturation of the transformer T3 or T4, phase angle + freq. will change	Loss of phase and freq. control on inverter output	0.2	
L6 or L7	short	C.F.	same as above	same as above	0.1	
Q17,18, 21 or 22	open	C.F.	Loss of one of the two oscillators	Loss of one output phase and change in the freq. of the other	4.0	
T4(1,2) or T4(2,3) or T5(1,2) or T5(2,3)	open	C.F.	same as above	same as above	0.4	
	short	C.F.	same as above	same as above		

STOMER NO. ______________

MODEL NO. EMIU104D

GULTON INDUSTRIES, INC.
Engineered Magnetics Division

FAILURE MODE AND FAILURE EFFECT ANALYSIS

ITEM	FAILURE MODE	SYSTEM EFFECT	SYMPTOMS AND LOCAL EFFECT INCLUDING DEPENDENT FAILURE	DETAIL EFFECT	PROBABILITY OF FAILURE/10^6 HOURS	REMARKS
T4(4,5)or T4(5,6)or T5(4,5)or	open	C.F.	Loss of one of the two oscillators	Loss of one output phase	.4	
T5(5,6)	short	C.F.	same as above	same as above	.2	
T3(10,11) or T5(11,12)	open	C.F.	Loss of two oscillators	Loss of output	.2	
T3(10,11) or T5(11,12)	short	C.F.	same as above	same as above	.2	

CUSTOMER NO. ______________

EM MODEL NO. EMIU104D

GULTON INDUSTRIES, INC.
Engineered Magnetics Division

VOLTAGE SENSE

V_{AB}

FAILURE MODE AND FAILURE EFFECT ANALYSIS

ITEM	FAILURE MODE	SYSTEM EFFECT	SYMPTOMS AND LOCAL EFFECT INCLUDING DEPENDENT FAILURE	DETAIL EFFECT	PROBABILITY OF FAILURE/10^6 HOURS	REMARKS
R86, 87, 76, or 77	open	D.F.	Output of the voltage sense circuit will increase	Will have no effect on the inverter; output voltage and impedance of the voltage sense circuit will increase	0.8	
C22, C18	open	D.F.	Ripple at the output of the voltage sense circuit will increase	Will have no effect on the inverter	0.1	
L10, L9	short	D.F.	same as above	same as above	0.2	
L10, L9	open	D.F.	Output of the volt. sense V_{AC} will be 0	same as above	0.2	
CR30 or 29 CR24 or 25	open	D.F.	Peak current through the diode will increase	Output of the volt. sense V_{AC} will have increased ripple	0.1	
CR30 or 29 CR24 or 25	short	C.F.	Fuse will clear the inverter	Inverter will not function	0.2	
C22 or 18	short	C.F.	same as above	same as above	0.1	

CUSTOMER NO. ________

EM MODEL NO. EMIU104D

GULTON INDUSTRIES, INC.
Engineered Magnetics Division

FAILURE MODE AND FAILURE EFFECT ANALYSIS

OVERCURRENT TIME PROTECTION

ITEM	FAILURE MODE	SYSTEM EFFECT	SYMPTOMS AND LOCAL EFFECT INCLUDING DEPENDENT FAILURE	DETAIL EFFECT	PROBABILITY OF FAILURE/10^6 HOURS	REMARKS
R80	open	D.F.	The overload protection timing will change from 5 ±.5 SEC to 7.5 ±.5 SEC	Will have no signif. effect on the inverter or pump motor assembly	.02	
R79	open	D.F.	The overload protection timing will change from 5 ±.5 SEC to 6.5 ±.5 SEC	same as above	.02	
R81 or 78	open	C.F.	The overload protection timing circuit will not work	In case of locked motor rotor, pump assembly may be damaged	.05	Double failure, motor and resistor
R82	open	C.F.	The overload time protection circuit will turn off the inverter without having experienced overload	By applying the turn on pulse, the invert. will come back on, but will again turn itself off after 5SEC as if locked motor condition existed	.05	
R84 or 84A	open	C.F.	CR26 or CR26A will turn on at much lower current than before, e.g. if R84 opens up, zener will turn on at approx. 7 A.	The overcurrent time protection circuit will turn off the inverter much sooner than 30A, e.g. 8A	.2	Will not start motor but will allow running operation

CUSTOMER NO. ______________

EM MODEL NO. EMIU104D

GULTON INDUSTRIES, INC.
Engineered Magnetics Division

OVERCURRENT TIME PROTECTION

FAILURE MODE AND FAILURE EFFECT ANALYSIS

ITEM	FAILURE MODE	SYSTEM EFFECT	SYMPTOMS AND LOCAL EFFECT INCLUDING DEPENDENT FAILURE	DETAIL EFFECT	PROBABILITY OF FAILURE/10^6 HOURS	REMARKS
C20	open or short	C.F.	The overload protection will not work	In case of locked motor rotor, pump assembly may be damaged	0.1	Double failure.
CR26	open	D.F.	Phase B or C overcurrent time protection will not work	Will have no effect on the inverter except one of the two overcurrent protections will not work	0.1	
CR26	short	C.F.	Overcurrent protection will work at a lower value of I_{line}	Turn off at running condition	0.5	
Q50	open	C.F.	Unijunction will free run, inverter will turn itself off after 5 MS	After applying turn on pulse, inverter will turn on for 5MS and will turn itself off	0.08	
Q50	short	D.F.	Capacitor C20 will be shorted so unijunction will never turn on	Inverter will never be able to sense locked motor rotor, pump motor assembly could be damaged	0.1	
CR27 or 28 CR36 or 37	open	D.F.	Diode will draw more peak current but will not be damaged	Overcurrent trip point will be changed higher than nominal set	0.15	

CUSTOMER NO. __________

EM MODEL NO. EMIU104D

GULTON INDUSTRIES, INC.
Engineered Magnetics Division

FAILURE MODE AND FAILURE EFFECT ANALYSIS

OVERCURRENT TIME PROTECTION

ITEM	FAILURE MODE	SYSTEM EFFECT	SYMPTOMS AND LOCAL EFFECT INCLUDING DEPENDENT FAILURE	DETAIL EFFECT	PROBABILITY OF FAILURE/10^6 HOURS	REMARKS
CR27-28	short	D.F.	AC applied across C21A, running load should be ok	Overcurrent trip point will be changed higher than nominal set	0.2	
T10(4,5) T10B(4,5)	open or short	C.F.	Phase B or C over-current time protection will not work	Loss of output from the inverter	0.2	
T10A(1,2) or T10A(2,3) or T10B(1,2) or T10B(2,3)	open	D.F.	Full wave C.T., diode will draw more peak current but will not be damaged	overcurrent trip point will be changed than nominal set valve	0.4	
	short	D.F.	Phase B or C over-current time protection will not work	No effect on the inverter	0.2	

CUSTOMER NO. ____________

EM MODEL NO. EMIU104D

GULTON INDUSTRIES, INC.
Engineered Magnetics Division

FAILURE MODE AND FAILURE EFFECT ANALYSIS POWER AMPLIFIER

ITEM	FAILURE MODE	SYSTEM EFFECT	SYMPTOMS AND LOCAL EFFECT INCLUDING DEPENDENT FAILURE	DETAIL EFFECT	PROBABILITY OF FAILURE/10^6 HOURS	REMARKS
Q25-48	open	D.F.	If any one of the transistors opened up, the rest of the transistor will be able to carry the load	There will be no significant effect on the inverter	4.0	
Q25-48	short	C.F.	Fuse will clear before any damage	No output from the inverter	20.0	
R53-75	open	D.F.	One of the transistor will be open rest of the trans. will be able to carry the load	No effect on the inverter	2.4	
T6(4,5) T6(10,11) T6(6,7) T6(8,9) T6(13,12) T6(15,14) T6(17,16) T6(19,18)	open	D.F.	The rest of the amplifiers will be able to carry the load	No effect on the inverter	0.8	
T7(4,5) T7(10,11) T7(6,7) T7(8,9) T7(13,12) T7(15,14) T7(17,16) T7(19,18)	open	D.F.	same as above	same as above	0.8	

USTOMER NO.

M MODEL NO. EMIU104D

GULTON INDUSTRIES, INC.
Engineered Magnetics Division

POWER AMPLIFIER

FAILURE MODE AND FAILURE EFFECT ANALYSIS

ITEM	FAILURE MODE	SYSTEM EFFECT	SYMPTOMS AND LOCAL EFFECT INCLUDING DEPENDENT FAILURE	DETAIL EFFECT	PROBABILITY OF FAILURE/10^6 HOURS	REMARKS
T7(4,5) T7(10,11) T7(6,7) T7(8,9) T7(13,12) T7(15,14) T7(17,16) T7(19,18)	open	D.F.	The rest of the amplifiers will be able to carry the load	No effect on the inverter	0.8	
T8(4,5) T8(10,11) T8(6,7) T8(8,9) T8(13,12) T8(15,14) T8(17,16) T8(19,18)	open	D.F.	same as above	same as above	0.8	
T6(4,5) T6(10,11) T6(6,7) T6(8,9) T6(13,12) T6(15,14) T6(17,16) T6(19,18)	short	C.F.	Fuse will clear before any damage	No out from the inverter	0.6	
T7(4,5) T7(10,11) T7(6,7) T7(8,9) T7(13,12) T7(15,14) T7(17,16) T7(19,18)	short	C.F.	same as above	same as above	0.6	

CUSTOMER NO. ____________

EM MODEL NO. EMIU104D

GULTON INDUSTRIES, INC.
Engineered Magnetics Division

FAILURE MODE AND FAILURE EFFECT ANALYSIS

POWER AMPLIFIER

ITEM	FAILURE MODE	SYSTEM EFFECT	SYMPTOMS AND LOCAL EFFECT INCLUDING DEPENDENT FAILURE	DETAIL EFFECT	PROBABILITY OF FAILURE/10^6 HOURS	REMARKS
T8(4,5) T8(10,11) T8(6,7) T8(8,9) T8(13,12) T8(15,14) T8(17,16) T8(19,18)	short	C.F.	Fuse will clear before any damage	No out from the inverter	0.6	
CR12-23	short	C.F.	same as above	same as above	0.8	
CR12-23	open	D.F.	The other parallel diode will be able to carry the load	No effect on the output	1.2	

CUSTOMER NO.
EM MODEL NO. EMIU104D

GULTON INDUSTRIES, INC.
Engineered Magnetics Division

FAILURE MODE AND FAILURE EFFECT ANALYSIS

RIPPLE REGULATOR

ITEM	FAILURE MODE	SYSTEM EFFECT	SYMPTOMS AND LOCAL EFFECT INCLUDING DEPENDENT FAILURE	DETAIL EFFECT	PROBABILITY OF FAILURE/10^6 HOURS	REMARKS
R2	open	C.F.	Forward bias to transistor Q3 will be missing, keeping pass transistors off	Ripple regulator will stay off, no output from the inverter	.02	
R1	open	C.F.	Transistor Q1 will be missing the drive required since Q2 will stay off	same as above	.02	
R98 or R4	open	C.F.	Transistor Q4 will always stay off thereby keeping Q1, Q2, and Q3 off	Ripple regulator will stay off, no output from the inverter	.02	
R29B or	open	D.F.	Output sense volt. will change, i.e. pass transistors will turn on before the preset value	Output of the ripple regulator will go down changing bias to the power amplifier; power output of the inverter will be slightly lower in amplitude		
R30	open	D.F.	Output voltage sense will be missing	Ripple regulator will stay on; output from the inverter not affected	.02	
R29A	open	C.F.	Q52 will always be on	Ripple regulator will always stay off, no output from inverter	0.2	

CUSTOMER NO.

EM MODEL NO. EMIU104D

GULTON INDUSTRIES, INC.
Engineered Magnetics Division

FAILURE MODE AND FAILURE EFFECT ANALYSIS

RIPPLE REGULATOR

ITEM	FAILURE MODE	SYSTEM EFFECT	SYMPTOMS AND LOCAL EFFECT INCLUDING DEPENDENT FAILURE	DETAIL EFFECT	PROBABILITY OF FAILURE/10^6 HOURS	REMARKS
R26	open	C.F.	Ripple regulator will loose its sense and comparison circuitry; pass transistor will always stay on	Efficiency of the inverter will go down and Q1 will dissipate more power than normal	.02	
R21 or R22	open	C.F.	Ripple regulator will loose its reference	Output of the ripple regulator will change and load current demand circuitry will not work; this will cause the driver stage to starve for current and shut off the inverter	.04	
R25	open	C.F.	Q52 will always be on	Inverter will stay off	.02	
R15 or R16	open	D.F.	Load current demand circuitry will regulate ripple regulator at lower voltage for higher current, which starves the driver for current	Inverter may shut off during starting load	.04	
R17 or R12 or R14	open	D.F.	Load current demand circuitry will not function	same as above	.08	

CUSTOMER NO. ____________

EM MODEL NO. EMIU104D

GULTON INDUSTRIES, INC.
Engineered Magnetics Division

RIPPLE REGULATOR

FAILURE MODE AND FAILURE EFFECT ANALYSIS

ITEM	FAILURE MODE	SYSTEM EFFECT	SYMPTOMS AND LOCAL EFFECT INCLUDING DEPENDENT FAILURE	DETAIL EFFECT	PROBABILITY OF FAILURE/10^6 HOURS	REMARKS
R7	open	C.F.	-DC bus will be open	no output from the inverter	.05	
CR5	open	C.F.	Ripple regulator will loose ref.	Regulator will stay off	1.0	
CR5	short	C.F.	Ripple regulator will change its reference voltage	same as above	3.0	
CR4	open	D.F.	Q6 will draw more current than present	Output of the volt. regulator will go up	1.0	
CR4	short	C.F.	Q6 will draw less current than preset	There will be no effect on the regulator	3.0	
Q1	open	C.F.	Ripple regulator will not work	No output from the inverter	2.0	
Q1	short	D.F.	Output of the ripple regulator is the same as input	Efficiency will go down, no current limiting	6.0	
Q2 or Q3	open	C.F.	Ripple regulator will not work	No output from the inverter	.16	
Q2 or Q3	short	D.F.	Q1 will be saturated all the time	Efficiency will go down and there will be no current limiting	.2	

CUSTOMER NO. ____________

EM MODEL NO. EMIU104D

GULTON INDUSTRIES, INC.
Engineered Magnetics Division

RIPPLE
REGULATOR

FAILURE MODE AND FAILURE EFFECT ANALYSIS

ITEM	FAILURE MODE	SYSTEM EFFECT	SYMPTOMS AND LOCAL EFFECT INCLUDING DEPENDENT FAILURE	DETAIL EFFECT	PROBABILITY OF FAILURE/10^6 HOURS	REMARKS
Q4	open	C.F.	Ripple regulator will not work	No output from the inverter	.08	
Q4	short	D.F.	Q1, Q2, and Q3 will always stay on	Efficiency will go down and there will be no current limiting	.1	
Q5	open	D.F.	Q4, Q1, Q2 and Q3 will always stay on	Efficiency will go down, no current limiting	.08	
Q5	short	C.F.	Ripple regulator will always be off	No output from the inverter	.1	
Q52	short	C.F.	same as above	same as above	.05	
Q52	open	D.F.	Pass transistor will always be on	Efficiency will go down and no current limiting	.02	
Q7	open	C.F.	Q1, Q2, Q3 and Q4 always off	No output from the inverter	.08	
Q7	short	C.F.	Ripple regulator will loose its ref.	same as above	.1	

USTOMER NO. ______

M MODEL NO. EMIU104D

GULTON INDUSTRIES, INC.
Engineered Magnetics Division

RIPPLE REGULATOR

FAILURE MODE AND FAILURE EFFECT ANALYSIS

ITEM	FAILURE MODE	SYSTEM EFFECT	SYMPTOMS AND LOCAL EFFECT INCLUDING DEPENDENT FAILURE	DETAIL EFFECT	PROBABILITY OF FAILURE/10^6 HOURS	REMARKS
Q6	open	D.F.	Current sense will	no effect on reg.	.02	
Q6	short	D.F.	Output of the volt. reg. will go up	lower efficiency of the inverter	.05	
Q51	open	C.F.	same as above	same as above	.02	
Q51	short	D.F.	Current sense will not work	No effect on reg.	.05	

3. Reliability Stress Analysis.

Engineered Magnetics Stress Analysis of the individual component parts of the EMIU104D Static Inverter is presented on pages 66 through 77.

Gulton Industries Inc.
EMD ENGINEERED MAGNETICS DIVISION HAWTHORNE, CALIFORNIA

RATING AND STRESS DATA
CAPACITORS

CONTRACTOR PESCO
SPEC NO. ____
EMD MODEL NO. EMIU104D

CIRCUIT SYMBOL	G.I. PART NO.	MFR.	MFR OR MIL TYPE	DIELECTRIC	*	RATED VALUES: CAPACITANCE	CAPACITANCE TOLERANCE (%)	WVDC AT 85°C (VOLTS)	WVDC AT 125°C. (VOLTS)	V_{RMS} OR V_{RIPPLE}	APPLIED VALUES: V_{DC} (VOLTS)	V_{RMS} OR V_{RIPPLE} (VOLTS)	TOTAL VOLTAGE (VOLTS)	FREQUENCY (HZ)	DUTY CYCLE (%)	STRESS RATIO V_{TOT}/V_{RTD}	FAILURE RATE IN BITS(10^{-8})	RELIABILITY RECOMMENDATIONS	REV
C1		SPRAGUE KEMET	CSR13F685KPU	Ta_2O_5		6.8	±10	35	23		3.2		3.2			.091			
C2,3		"	CSR13E156KPU	Ta_2O_5		15.0	±10	20	13							NIL		BLOCKING CAPACITOR FOR TURN-ON PULSE	
C7		ELECTRO CUBE	625B1B472J	Metal. Polycarb.		0.0047	±5	100	50		2		2			.02			
C6		"	625B1B682J	"		0.0068	±5	100	50		1.4		1.4			.014			
C8A,8B	GI75576-4	GE	29F	Ta Foil		280	+75 -15	75	50		41.0	0.1	41.1	$6x10^3$	50	.54			
C9	EM79474-6	GE	16K	Ta Foil		30	+75 015	75	50		46.7		46.7		50	.62			
C10B	GI75576-34	GE	29F	Ta Foil		660	+75 -15	75	50		60	0.2	60.2	400	50	.80			
C10A	GI75576-34	GE	29F	TaFoil		660	+75 -15	75	50		59.5	1.0	60.5	1200	50	.81			
C11		SPRAGUE	118P33392S2	Metal.paper & Polyester		0.033	±10	200	200			3.55	3.55	400	50	.018			
C12,13		"	118P22302S1	"		0.022	±20	200	200			35	35	400	50	.18			
C14	EM78381-12	SPRAGUE DEAR.DIV.	LP8A1	Polycar- bonate		0.5	±5	200	200			21.8	21.8	400	50	.11			
C15		SPRAGUE KEMET	CSR13C396KPU	Ta_2O_5		39	±10	10	7		2.25	0.15	2.4	$6x10^3$	50	.24			
C16		"	CSR13F226KPU	Ta_2O_5		22	±10	35	23		14.0		14.0			.40			
C23, C17,19		SPRAGUE	118P47402S2	Metal.paper & Polyester		0.47	±20	200	200			27		400	50	.14			
C18,22		SPRAGUE KEMET	CSR13C127KPU	Ta_2O_5		120	±10	10	7		4.95		4.95			.495			
C24		ELECTRO CUBE	625B1B224J	Metal. Polycarb.		0.22	±5	100	50		40		40			.40			
C25		SPRAGUE KEMET	CSR13E225KPU	Ta_2O_5		2.2	±10	20	13		2.5		2.5			.10			
C26,27	EM77308-4	GULTON GLEN. DIV.		Ceramic		2	±20	100	50		30		30			.30			
C28		ELECTRO CUBE	625B1B223J	Metal. Polycarb.		0.022	±5	100	50			0.5	0.5	$6x10^3$	50	.005			
C29		"	625B1B332J	"		0.0033	±5	100	50			0.5	0.5	$6x10^3$	50	.005			
C30		"	625B1B332J	"		0.0033	±5	100	50		27		27			.27			

* P-PULSE, AC-ALTERNATING F-FILTER, DC-DIRECT CURRENT

Gulton Industries Inc.
EMD ENGINEERED MAGNETICS DIVISION HAWTHORNE, CALIFORNIA

RATING AND STRESS DATA
CAPACITORS

CONTRACTOR PESCO

SPEC NO.

EMD MODEL NO. EMIU104D

CIRCUIT SYMBOL	G.I. PART NO.	MFR.	MFR OR MIL TYPE	DIELECTRIC	*	RATED VALUES: CAPACITANCE	RATED VALUES: CAPACITANCE TOLERANCE (%)	RATED VALUES: WVDC AT 85°C (VOLTS)	RATED VALUES: WVDC AT 125°C. (VOLTS)	RATED VALUES: V_{RMS} OR V_{RIPPLE}	APPLIED VALUES: V_{DC} (VOLTS)	APPLIED VALUES: V_{RMS} OR V_{RIPPLE} (VOLTS)	APPLIED VALUES: TOTAL VOLTAGE (VOLTS)	APPLIED VALUES: FREQUENCY (HZ)	APPLIED VALUES: DUTY CYCLE (%)	APPLIED VALUES: STRESS RATIO V_{TOT}/V_{RTD}	APPLIED VALUES: FAILURE RATE IN BITS(10-8)	RELIABILITY RECOMMENDATIONS	REV
C4		SPRAGUE KEMET	CSR13F68KPU	Ta_2O_5		6.8	±10	35	23		4.6		4.6			.13			
C5		"	CSR13F685KPU	Ta_2O_5		6.8	±10	35	23		2.0		2.0			.057			
C20		"	CSR13C396KPU	Ta_2O_5		39	±10	10	7		0.3		0.3	ONE PULSE	NIL	.03		SEE 8 VOLTS TURN-ON PULSE	
C31		ELECTRO CUBE	625B1B223J	Metal. Polycarbon.		0.022	±5	100	50		1.4					.014			
C21, C21A		KEMET SPRAGUE	CSR13F226KPU	Ta_2O_5		22	±10	35	23		5					.143			

* P-PULSE, AC-ALTERNATING F-FILTER, DC-DIRECT CURRENT

Gulton Industries Inc.
EMD ENGINEERED MAGNETICS DIVISION HAWTHORNE CALIFORNIA

RATING AND STRESS DATA
DIODES

CONTRACTOR PESCO
SPEC NO.
EMD MODEL NO. EM1U104D

CIRCUIT SYMBOL	G.I. PART NO.	MFG	MFG OR MIL TYPE		V_R VOLT APPLIED / RATED	I_R mA APPLIED / RATED	I_{PEAK} mA APPLIED / RATED	$I_{AVERAGE}$ (FORWARD) mA APPLIED / RATED	DUTY CYCLE T_{ON} / T_{OFF}	P_{TOTAL} (AVERAGE) WATTS APPLIED / RATED	P_{PEAK} APPLIED / RATED	FAILURE RATE IN BITS (10^{-8})	RELIABILITY RECOMMENDATIONS	REV
CR1	EM74808H1	TI	U-643 or 1N3886		60 150	18µA	$2.5x10^3$ $12x10^3$	$0.8x10^3$ $12x10^3$	50 50	1.0 18				
CR2			1N645		2.8 225	.2µA	1.25A	400		600 mW				
CR3			1N645		225	.2µA	7.0 1.25A	7.0 400	100 0	7mW 600mW				
CR4	EM79430H	(SEE Zener	Diodes)						100 0					
CR5	"	" "	"						100 0					
CR6	EM79430H	(SEE Zener	Diodes)						100 0					
CR7			1N645		0 225	0 .2µA	0.0039 1.25A	0.0030 400	100 0	.0039mW 600mW				
CR8,9			1N645		0.8 225	0 .2µA	100 1.25A	35 400	50 50	20mW 600mW				
CR10,11			1N645		30 225	.2µA	4 1.25A	2 400	50 50	1mW 600mW				
CR12-23			1N1202		60 200	2	$25x10^3$ $240x10^3$	8×10^3 $12x10^3$	50 50	10.8				
CR24,25, 29,30			1N645		18 225	.2µA	7 1.25A	3 400	66.6 33.3	2mW 600mW				
CR27,28 36,37			1N645		12.5 225	.2µA	20 1.25A	9 400	50 50	5mW 600mW				
CR31			1N645		225	.2-A	1 1.25A	1 400	100 0	1mW 600mW				
CR32,33			1N645		225	.2µA	1.25A	400		600mW				
CR34,35	EM76014-1H	GE	1N2612		6.8 200	1µA	0.5 850	0.25 850	50 50	.12mW 1				
CR26	EM79430H	(SEE Zener	Diodes)											

Gulton Industries Inc.
EMD ENGINEERED MAGNETICS DIVISION
HAWTHORNE CALIFORNIA

CONTRACTOR PESCO

SPEC NO.

EMD MODEL NO. EM1UI04D

RATING AND STRESS DATA
ZENER DIODES

CIRCUIT SYMBOL	TYPE NO.	MANUFACTURER	MAXIMUM RATED POWER	ACTUAL ZENER CURRENT	ZENER VOLTS MAX.	ZENER VOLTS MIN.	MAX. RATED TEMP. °C	TEMP. COEFF. (%) °C	ACTUAL POWER DISS.	STRESS RATIO	FAILURE RATE IN BITS (10^{-8})	RELIABILITY COMMENTS
CR4	EM79430H	TRW (PS 35504)	400	4	6.93	6.27	175	±.005	26.4	.066		
CR5	EM79430H	TRW	400	4.6	6.93	6.27	175	±.005	30.36	.076		
CR6	EM79430H	TRW	400	2.25	6.93	6.27	175	±.005	14.85	.037		
CR26	EM79430H	TRW	400	2.33	6.93	6.27	175	±.005	15.38	.039		

Gulton Industries Inc.
EMD ENGINEERED MAGNETICS DIVISION HAWTHORNE CALIFORNIA

RATING AND STRESS DATA
INDUCTORS

CONTRACTOR PESCO
SPEC NO.
EMD MODEL NO. EMIU104D

CIRCUIT SYMBOL G.I. PART NO.	INSUL. CLASS TEMP.	WINDING	WIRE RATING: BREAKDOWN Δ VOLTAGE, TURN TO TURN (VOLTS) APPLIED	WIRE RATING: BREAKDOWN Δ VOLTAGE, TURN TO TURN (VOLTS) RATED	WIRE RATING: CURRENT APPLIED CURRENT (AMPS)	WIRE RATING: CURRENT DUTY CYCLE	INSULATION VOLTAGE RATING BETWEEN WINDING (s) OR CORE (VOLTS)	CORE VOLTAGE* SUPPORT (VOLTS)	CORE VOLTAGE* APPLIED (VOLTS)	FREQUENCY (HZ)	DC RESISTANCE (OHMS)	INDUCTANCE (MH)	TEMP. RISE (ΔT) (°C)	REMARKS
L2A, L2B	R	1 - 2	<1	62	5	100%	500		.04	1200	<0.01		<5°C	INPUT FILTER
L1	R		<1	62	5	100%	500		.03	1200	<0.01		<5°C	CHOKES
L3	R		<1	62	5	100%	500		.03	1200	<0.01		<5°C	
L4	R		2	23	1.2	80%	500		0.1	10K			<5°C	20V TOTAL
L5	R		1	23	0.4	100%	500		24	400			<5°C	FREQUENCY DETERMINING ELEMENT.
L8	R		1	23	.00025	100%	500		0.2	10K			<5°C	
L9, L10	R		1	14	.003	100%	500	10	4.2	800	100	0.5	<5°C	
L11A,B,C	R		1	62	2.5 AP 1.2	100%	500		29	400			<5°C	

Δ THE HIGHEST VOLTAGE USUALLY OCCURS AT THE INSTANT THE TOTAL VOLTAGE IS APPLIED TO THE CIRCUIT.

*$E=4A_C E B_M NS \times 10^{-8}$ (V) FOR ⊓⊔, $E=4.44A_C F B_M NS \times 10^{-8}$ (V) FOR ∿ -FOR AC ONLY.

Gulton Industries Inc.
EMD ENGINEERED MAGNETICS DIVISION HAWTHORNE, CALIFORNIA

RATING AND STRESS DATA
SATURABLE REACTORS

CONTRACTOR PESCO
SPEC NO.
EMD MODEL NO. EMIU104D

CIRCUIT SYMBOL G.I. PART NO.	INSUL CLASS TEMP.	WINDING	WIRE RATING: BREAKDOWN VOLTAGE, TURN TO TURN (VOLTS)		WIRE RATING: CURRENT		INSULATION VOLTAGE RATING BETWEEN WINDING (s) OR CORE (VOLTS)	CONTROL WINDING *		FREQUENCY (HZ)	WINDING RESISTANCE (OHMS)	COPPER LOSS (WATTS)	REMARKS
			APPLIED	RATED	APPLIED CURRENT (AMP)	DUTY CYCLE		SUPPORT (VOLTS)	APPLIED (VOLTS)				
L6	R		<1	23	0.5	10%	500			400			PROVIDES SMALL DELAY FOR
L7	R		<1	23	0.5	10%	500			400			PHASE CONTROL.

* $E = 4 A_C F B_M NS \times 10^{-8}$ (V) FOR ⊓⊔, $E = 4.44 A_C F B_M NS \times 10^{-8}$ (V) FOR ∿ - FOR DRIVE WINDING ONLY.

Gulton Industries Inc.
EMD ENGINEERED MAGNETICS DIVISION HAWTHORNE CALIFORNIA

CONTRACTOR PESCO

SPEC NO.

EMD MODEL NO. EMIU104D

RATING AND STRESS DATA
TRANSISTORS

CIRCUIT SYMBOL	G.I. PART NO.	MFG.	TYPE	V_{CE} NORMAL OFF VOLTAGE APPLIED / RATED	V_{CE} VOLTS (PEAK) APPLIED / RATED	V_{EB} (VOLTS) APPLIED / RATED	I_C MILLIAMPS PEAK APPLIED / RATED	I_C MILLIAMPS AVERAGE APPLIED / RATED	DUTY CYCLE T_{ON} / T_{OFF}	P_{TOTAL} (AVERAGE) WATTS APPLIED / RATED	P_{PEAK} (WATTS) APPLIED / RATED	FAILURE RATE IN BITS (10^{-8})	RELIABILITY COMMENTS	REV
Q1	GI711347H	TI	NPN-POWER	60	66	0.8	2.6×10^{3}	1.2×10^{3}	60	0.5	200/.2μS			
			857M-4	100	120	7	30×10^{3}	20×10^{3}	40	67	1000/500μS			
Q2	GI78324H	SOLITRON	2N2658	62	62	0.8	0.634×10^{3}	0.32×10^{3}	60	0.08	12.5/.2μS			
				80	80	8	7.5×10^{3}	5×10^{3}	40	1.25	450/1μS			
Q3	GI711477H	MOT	2N3635	64	64	0.7	80	40	60	0.06	26.6/.3μS			
				140	140	5	1000	1000	40	1				
Q4	GI73531H-2	RAY	2N2102	60	60	0.8	3.42	1.1	50	0.01	0.03			
		RCA		80	80	7	1000	1000	50	1	1			
Q5	GI73531H-2	"	2N2102	0.8	0.8	0.6	1.0	0.5	50	$.8 \times 10^{-3}$				
				80	80	7	1000	1000	50	1				
Q6	GI73531H-2	"	2N2102	38	38	0.7	0.46	0.46	100	0.0175	0.0175			
				80	80	7	1000	1000	0	1	1			
Q7	GI711477H	MOT	2N3635	24	26	0.7	0.37	0.3	100	0.0072	0.0072			
				140	140	5	1000	1000	0	1				
Q51	GI73531H-2	RAY	2N2102	22	23	0.7	3.0	3.0	100	0.0066	0.0066			
		MOT		80	80	7	1000	1000	0	1	1			
Q52	GI711477-H	MOT	2N3635	18	28	0.7	0.34	0.2	50	2.2×10^{-3}	4.5×10^{-3}			
				140	140	5	1000	1000	50	1	1			
Q8	GI73531H-2	RAY	2N2102	0.2	0.2	0.65	1.0	1.0	100	0.2×10^{-3}	0.2×10^{-3}			
		RCA		80	80	7	1000	1000	0	1	1			
Q9	GI73531H-2	"	2N2102	45	45	0	0	0	0	NIL				
				80	80	7	1000	1000	100	1	1			
Q10	GI711477H	MOT	2N3635	0.7	0.7	0.75	14	14	100	9.8×10^{-5}	9.8×10^{-3}			
				140	140	5	1000	1000	0	1	1			
Q11		FAIRCHILD	2N5001	13.6	13.6	0.7	55	55	100	0.75	0.75			
				80	80	5	2000	2000	0	30	30			
Q12	GI73531H-2	RAY	2N2102	55	56	0.7	0.22	0.22	100	12.3×10^{-3}	12.3×10^{-3}			
		RCA		80	80	7	1000	1000	0	1	1			
Q13,14	GI73531-120H	"	2N2102	96	98	1.0	23	11.5	50	1.8×10^{-3}	45			
				120	120	7	1000	1000	50	1	1			
Q15,16,19,	EM710438H1	WESTING-	2N3431	87	87	3.6	510	255	50	0.13	0.26			
20,23,24		HOUSE		120	120	8	10×10^{3}	7.5×10^{3}	50	40	550/100μS			
Q17,18,	GI73531-120H	RAY	2N2102	96	110	2.0	18	9	50	20×10^{-3}	100/.2μS			
21,22		RCA		120	120	7	1000	1000	50	1				
Q25-48	EM79807	WESTING-	2N2771	60	60	2.3	2.5×10^{3}	1.2×10^{3}	50	1.65	480/2μS			
		HOUSE		100	100	10	40×10^{3}	40×10^{3}	50	200	3000/50μS			
Q49	EM74762H	GE	UNIJUNCTION	15	15	0.3	1.5	1.5	100	22.4×10^{-3}	22.4×10^{-3}			
			2N2420A	60	60	20	70	70	0	450×10^{-3}	450×10^{-3}			
Q50	GI74706H	MOT	2N2222	0.3	0.3	0.4	0.087	0.087	100	0.26×10^{-3}	0.26×10^{-3}			
		RAY		40	40	5	500	500	0	500×10^{-3}	500×10^{-3}			

Gulton Industries Inc.
EMD ENGINEERED MAGNETICS DIVISION HAWTHORNE, CALIFORNIA

RATING AND STRESS DATA
RESISTORS

CONTRACTOR PESCO

SPEC NO.

EMD MODEL NO. EM1U104D

CIRCUIT SYMBOL	G.I. PART NO.	MFR.	MFR'S PART NO.	MIL TYPE		RATED VALUES: RESISTANCE (OHMS)	RESISTANCE TOLERANCE (%)	POWER (MW) AND VOLTAGE DC	MAX TEMP FOR MAX POWER (°C)	TEMP FOR ZERO POWER (°C)	APPLIED VALUES: I_{DC} (MA)	V_{DC} (VOLTS)	V_{RMS} (VOLTS)	DUTY CYCLE	POWER (MW)	STRESS RATIO	FAILURE RATE IN BITS (10^{-8})	RELIABILITY COMMENTS	REV
R1		DALE	RS2B-3Ω			3.0	±1	3000 135	25	275	250		0.75	187.5	.063				
R2		DALE	RS2B-12.5Ω			12.5	±1	3000 135	25	275	45		0.45	20.25	.0068				
R3		CORNING	RN55C7872F	MIL-2-10509		78.7K	±1	100 200	125	175	0.76	60		45.6	.46				
R4		"	RN55C7872F	"		17.5K	±1	100 200	125	175	1.14		20	22.8	.23				
R5		CORNING	RN55C1211F	MIL-R-10509		1.21K	±1	100 200	125	175	2.4	3.02		7.25	.073				
R7						0.005	±1				19.5x10^3	0.1	0.1	1950					
R8		CORNING	RN55C1000F	MIL-R-10509		100	±1	100 200	125	175	5	0.5	0.5	2.5	.025				
R9		"	RN55C5110F	"		511	±1	100 200	175	175	0.98		0.5	.49	.0049				
R10		"	RN55C2151F			2.15K	±1	100 200	125	175	1.3	2.5	0.3	3.64	.036				
R11		CORNING	RN55C3651F	MIL-R-10509		3.65K	±1	100 200	125	175	0.97	2.15	0.4	3.44	.034				
R12		DALE	RS2B-5KΩ			5K	±1	3000 135	25	275	7.0	35		245	.082				
R13		CORNING	RN55C2871F	MIL-R-10509		2.87K	±1	100 200	125	175	1.39	4.0		5.56	.056				
R14		"	RN55C2151F	""		2.15K	±1	100 200	125	175	1.81	4.0		7.24	.072				
R15		"	RN55C2051F	"		2.05K	±1	100 200	125	175	1.19	2.3	0.15	2.92	.029				
R16		"	RN55CXXXXF	"		SIT 5K	±1	100 200	125	175	0.49	2.3	0.15	1.20	.012				
R17		"	RN55C5621	"		5.62K	±1	100 200	125	175	3.04	17.0	0.5	53.2				CHANGE TO RN60C	
R18		"	RN55C2151F	"		2.15K	±1	100 200	125	175	0.605	1.3		.787	.0079				
R19		"	RN55C5360F	"		536	±1	100 200	125	175	3.54	1.9		6.73	.067				
R20		"	RN55C1781F	"		1.78K	±1	100 200	125	175	1.37	2.45		3.36	.034				
R21		CORNING	RN55C8660F	MIL-R-10509		866	±1	100 200	125	175	5.3	4.6		24.38	.244				
R22		DALE	RS2B-6.5K			6.5K	±1	3000 135	25	275	4.62	30		138.6	.046				

Gulton Industries Inc.
EMD ENGINEERED MAGNETICS DIVISION
HAWTHORNE, CALIFORNIA

RATING AND STRESS DATA
RESISTORS

CONTRACTOR PESCO

SPEC NO.

EMD MODEL NO. EMIU104D

CIRCUIT SYMBOL	G.I. PART NO.	MFR.	MFR'S PART NO.	MIL TYPE		RATED VALUES: RESISTANCE (OHMS)	RESISTANCE TOLERANCE (%)	POWER (MW) AND VOLTAGE DC	MAX TEMP FOR MAX POWER (°C)	TEMP FOR ZERO POWER (°C)	APPLIED VALUES: I_{DC} (MA)	V_{DC} (VOLTS)	V_{RMS} (VOLTS)	DUTY CYCLE	POWER (MW)	STRESS RATIO	FAILURE RATE IN BITS (10^{-8})	RELIABILITY COMMENTS	REV
R23		CORNING	RN55C5112F	MIL-R-10509		51.1K	±1	100 200	125	175	1.17	60		70.2				CHANGE TO RC07	
R24		"	RN55C2492F	"		24.9K	±1	100 200	125	175	0.28	3	4	3.36	.034				
R25		"	RN55C2742F	"		27.4K	±1	100 200	125	175	0.365	10		3.65	.037				
R26		"	RN55C6492F	"		64.9K	±1	100 200	125	175	0.17		11	1.87	.019				
R27		"	RN55C2493F	"		249K	±1	100 200	125	175	≈0	0.2							
R28		"	RN55C3013F	"		301K	±1	100 200	125	175	0.13	40		5.2	.052				
R29		"	RN55C3482F	"		34.8K	±1	100 200	125	175	0.288	10		28.8	.288				
R30		"	RN55C8252F	"		82.5K	±1	100 200	125	175	0.346	28.5		9.86	.099				
R31		"	RN55C1403F	"		140K	±1	100 200	125	175	0.07	10		.7	.007				
R32		"	RN55C4221F	"		4.22K	±1	100 200	125	175	0.261	1.0	0.1	.287	.0029				
R33		"	RN55C2052F	"		20.5K	±1	100 200	125	175	2.0	40		80.0				CHANGE TO RCR07	
R34		"	RN55C1003F	"		100K	±1	100 200	125	175	0.4	40		16.0	.16				
R35		"	RN55C3002F	"		30K	±1	100 200	125	175	0.211	6.35		1.34	.0134				
R36		"	RN55C3012F	"		30.1K	±1	100 200	125	175	1.31	39.5		51.75				CHANGE TO RN60C	
R37		"	RN55C5361F	"		5.36K	±1	100 200	125	175	1.18	6.35		7.49	.075				
R38		"	RN55C1272F	"		12.7K	±1	100 200	125	175	1.97		25	49.25	.493				
R39		"	RN55C1001F	"		1K	±1	100 200	125	175	0.5		0.5	.25	.0025				
R40		CORNING	RN55C1272F	MIL-R-10509		12.7K	±1	100 200	125	175	1.97		25	49.25	.493				
R41,42,46, 47,51,52		DALE	RS2B-20Ω			20	±1	3000 135	25	275	0.065		1.3	.0845	.001				
R43,44, 48,R49		DALE	RS2B-35Ω			35	±1	3000 135	25	275	0.024		0.84	.0202	.001				
R45,R50		CORNING	RN55C5112F	MIL-R-10509		51.1K	±1	100 200	125	175	0.9		46	41.4	.414				

FORM EMD 215534-5

Gulton Industries Inc.
EMD ENGINEERED MAGNETICS DIVISION
HAWTHORNE, CALIFORNIA

CONTRACTOR PESCO

SPEC NO.

EMD MODEL NO. EM1U104D

RATING AND STRESS DATA
RESISTORS

CIRCUIT SYMBOL	G.I. PART NO.	MFR.	MFR'S PART NO.	MIL TYPE	RATED VALUES: RESISTANCE (OHMS)	RESISTANCE TOLERANCE (%)	POWER (MW) AND VOLTAGE DC	MAX TEMP FOR MAX POWER (°C)	TEMP FOR ZERO POWER (°C)	APPLIED VALUES: I_{DC} (MA)	V_{DC} (VOLTS)	V_{RMS} (VOLTS)	DUTY CYCLE	POWER (MW)	STRESS RATIO	FAILURE RATE IN BITS (10^{-8})	RELIABILITY COMMENTS	REV
R29A		DALE	WWA-13-18	MIL-R-39005 MIL-R-93	1.5K	±1	125 50	125	145	0.4	0.6		.24	.0019				
R53-75		DALE	RS-5-.75Ω		0.75	±1	5000 330	25	275	1.17x 10^{3}		0.7	819	.164				
R76,86		CORNING	RN55C1471F	MIL-R-10509	1.47K	±1	100 200	125	175	3.2	5.0		16.0	.16				
R77,87		"	RN55C3001F	"	3K	±1	100 200	125	175	1.66	5.0		8.30	.083				
R78		"	RN55C4640F	"	464	±1	100 200	125	175	1.5	0.7		1.05	.0105				
R79		"	RN55C1963F	"	196K	±1	100 200	125	175	0.012	2.0		.024	<.001				
R80		"	RN55C2872F	"	28.7K	±1	100 200	125	175	0.071	2.0		.142	.0014				
R81		"	RN55C1403F	"	140K	±1	100 200	125	175	0.089	12.5		.111	.0011				
R82		"	RN55C3012F	"	30.1K	±1	100 200	125	175	0.467	14.0		6.54	.065				
R83		"	RN55C3831F	"	3.83K	±1	100 200	125	175	0.083	0.32		.0266	<.001				
R84, 84A		"	RN55C3000F	"	300	±1	100 200	125	175	1.66	5.0		8.3	.083				
R85, 85A		"	RN55C1001F	"	1K	±1	100 200	125	175	5	5.0		25.0	.25				
R88,92		CORNING	RN55C3000F	MIL-R-10509	300	±1	100 200	125	175	3.32	1.0		3.32	.033				
R89		DALE	WWA-13-18	"	5K	±1	125 50	125	145	0.06	0.3		.018	<.001				
R90		CORNING	RN55C9091F	MIL-R-10509	9.09K	±1	100 200	125	175	0.132	1.2		.158	.0016				
R91		"	RN55C4642F	"	46.4K	±1	100 200	125	175	0.258	12		3.096	.031				
R93		CORNING	RN55C2151F	MIL-R-10509	2.15K	±1	100 200	125	175	0.232	0.5		.116	.0012				
R94		DALE	RS2B-4K		4K	±1	3000 135	25	275	14.7	59		867.3	.289				
R95		CORNING	RN55C8660F	MIL-R-10509	866	±1	100 200	125	175	0.23			.046	<.001				
R97		CORNING	RN55C1963F	MIL-R-10509	196K	±1	100 200	125	175									
R96		"	RN55C3011F	"	3.01K	±1	100 200	125	175	0.166	0.5		.083	<.001				

Gulton Industries Inc.
EMD ENGINEERED MAGNETICS DIVISION HAWTHORNE CALIFORNIA

RATING AND STRESS DATA
TRANSFORMER

CONTRACTOR PESCO
SPEC NO.
EMD MODEL NO. EMIU104D

CIRCUIT SYMBOL G.I. PART NO.	INSUL. CLASS TEMP.	WINDING	WIRE RATING: VOLTAGE, TURN TO TURN (VOLTS) APPLIED	RATED	APPLIED CURRENT (AMP)	DUTY CYCLE	VOLTAGE BETWEEN WINDING (s) OR CORE (VOLTS) APPLIED	RATED	CORE VOLTAGE*: SUPPORT (VOLTS)	APPLIED (VOLTS) RMS	CORE LOSS Δ (WATTS)	WINDING RESISTANCE R_{dc} (OHMS)	COPPER LOSS ~~(WATTS)~~ (mW)	TOTAL POWER LOSS ∇ (WATTS)	∇T TEMP RISE ABOVE AMBIENT (°C)	REMARKS
T3	R	1 - 2 & 2 - 3	<1 (50V Total)	23	$12x10^{-3}$	50%	<50	1000	54	47.0	$34x10^{-3}$	74.0	10.7	94.4mW		
T3	"	4 - 5	<1	23	$50x10^{-3}$			"	4.65	4.0		7.4	18.5			
T3	"	6 - 7 & 8 - 9	<1	62	67.5x $10x^{-3}$			"	4.08	2.1		2.5	9.55			
T3	"	10 - 11	<1	62	$25x10^{-3}$			"	5.14	4.4		1.51	.945			
T3	"	12 - 13& 13 - 14	<1	23	$2x10^{-3}$			"	17.8	15.0		31.8	.128			
T3	"	15 - 16	<1	23	0.38x 10^{-3}			"	4.85	4.1		9.37	1.4µW			
T4 & T5	"	1 - 2 & 2 - 3	<1	23	$10x10^{-3}$			"	54	47	$34x10^{-3}$	74.0	7.4	73.1mW		
"	"	4 - 5 & 5 - 6	<1	23	$25x10^{-3}$			"	4.16	2.0		3.68	2.3			
T4 & T5	"	7 - 8 & 9 - 10	<1	62	67.5x 10^{-3}			"	4.16	2.1		2.5	9.55			
T6	"	1 - 2 & 2 - 3	<1 (50V Total)	85	0.255			"	52.2	40.0	158.5x 10^{-3}	3.24	213	1.069W		
"	"	4-5, 6-7, 8-9,	<.01 (3V Total)	144	1.0			"	3.35	2.25		0.060	60			
		10-11 12-13,														
		14-15, 16-17,														
		18-19.														
T6	"	20-21 & 21-22	<.01 (7V Total)	23	0.25			"	4.6	3.5		0.12	7.5			
T7 & T8	"	1 - 2 & 2 - 3	<1	85	0.255			"	52.2	40.0	158.5x 10^{-3}	3.24	2.3	1.054W		
T7 & T8	"	4-5, 6-7, 8-9,	<1	144	1.0	50%		"	3.35	2.25		0.06	60			
		10-11, 12-13.					<50									

Δ AT FREQUENCY OF OPERATION FOR DRIVE WINDING ONLY

*$E = 4A_C F B_M NS \times 10^{-8}$(V) FOR ⊓⊔, $E = 4.44 A_C F B_M NS \times 10^{-8}$(V) FOR ∿ – FOR DRIVE WINDINGS ONLY

∇ TOTAL POWER LOSS = CORE LOSS + $\sum_{n=1}^{n} R_{dc} \times Irms^2$, WHERE Irms IS DETERMINED FOR EACH WINDING

Gulton Industries Inc.
EMD ENGINEERED MAGNETICS DIVISION HAWTHORNE CALIFORNIA

RATING AND STRESS DATA
TRANSFORMER

CONTRACTOR PESCO
SPEC NO.
EMD MODEL NO. EMIU104D

CIRCUIT SYMBOL G.I. PART NO.	INSUL. CLASS TEMP.	WINDING	WIRE RATING: VOLTAGE, TURN TO TURN (VOLTS) APPLIED	VOLTAGE, TURN TO TURN (VOLTS) RATED	APPLIED CURRENT (AMP)	DUTY CYCLE	VOLTAGE BETWEEN WINDING (s) OR CORE (VOLTS) APPLIED	VOLTAGE BETWEEN WINDING (s) OR CORE (VOLTS) RATED	CORE VOLTAGE* SUPPORT (VOLTS)	CORE VOLTAGE* APPLIED (VOLTS)	CORE LOSS Δ (WATTS)	WINDING RESISTANCE R_{dc} (OHMS)	COPPER LOSS (WATTS)	TOTAL POWER LOSS ∇ (WATTS)	∇T TEMP RISE ABOVE AMBIENT (°C)	REMARKS
T1 & T2	R	1 - 2	1	20	$4.1\text{x}\ 10^{-3}$			1000		3.4v/3ms		71.0		10mW		
T1 & T2	R	3 - 4	1	20	$4.1\text{x}\ 10^{-3}$			1000		3.4v/3ms		71.0				
T7 & T8	R	14-15, 16-17, 18-19.	1	144	1.0	50%		1000	3.35	2.25	$158.5\text{x}\ 10^{-3}$	0.06	60			
T9 & T11	"	1 - 2	0.15	23	$1.1\text{x}\ 10^{-3}$	100%		"	58	30.0	$9.6\text{x}\ 10^{-3}$	167.1	0.202	10.2mW		
T9 & T11	"	3 - 4 & 4 - 5	0.15	23	$3.5\text{x}\ 10^{-3}$	100%		"	8.9	5.0		33.1	0.407			
T10A, 10B	"	4 - 5	1	20	17.1	90%		"		0.021		R 0.001		10mW		
T10A, 10B	"	1 - 2 & 2 - 3	1	20	$9\text{x}10^{-3}$	90%		"		5.75		7.3		10mW		

Δ AT FREQUENCY OF OPERATION FOR DRIVE WINDING ONLY

*$E = 4A_C F\ B_M NS \times 10^{-8}$ (V) FOR ⊓⊔, $E = 4.44 A_C F\ B_M NS \times 10^{-8}$ (V) FOR ∿ - FOR DRIVE WINDINGS ONLY

∇ TOTAL POWER LOSS = CORE LOSS + $\sum_{n=1}^{n} R_{dc} \times \text{Irms}^2$, WHERE Irms IS DETERMINED FOR EACH WINDING

E. Electrical Performance Tests

Waveform photographs obtained during tests performed on the breadboard model are presented in Appendix II.

Each Static Inverter was subjected to and passed, an Acceptance Test in accordance with Engineered Magnetics Acceptance Test Procedure 712954, prior to shipment to Pesco Products. A complete set of Acceptance Test Record Forms showing the Acceptance Test results of EMIU104D Static Inverter Serial No. 25501 are presented in Appendix II.

Specific input and output data obtained during the Acceptance Tests performed on each of the seven Static Inverters are presented on the following table. (Specified requirements are in parentheses).

		EMIU104D UNIT SERIAL NUMBER						
		25505	25506	25507	25508	25509	25510	25511
INPUT: 56VDC CURRENT (A)		9.6	9.8	9.8	10.0	10.0	9.8	9.9
POWER (W)		537.6	548	548	560	560	548	554
OUTPUT VOLTAGE RMS LINE TO NEUTRAL	ØA	26.0	26.47	26.56	26.32	26.43	26.11	26.43
	ØB	25.9	26.34	26.46	26.12	26.25	25.97	26.21
	ØC	26.0	26.50	26.66	26.38	26.38	26.30	26.34
FREQ (Hz) (396-404)		400	399	399	398	399	399	399
PHASE DISPLACEMENT (°) (120°±5°) (AT RUNNING LOAD)	ØA-B	120.19	119.7	119.8	119.5	118.6	119.8	119.1
	ØA-C	119.55	120.1	120.5	120.0	119.6	119.6	120.6
	ØC-A	120.23	120.2	119.8	120.6	120.2	120.6	120.5
EFFICIENCY (%) (85% MIN.)		94.5	95.2	97.0	97.8	92.5	95.6	94.2
OVERLOAD OUTPUT CURRENT	ØA	28.5	29.5	29.5	29.0	29.0	28	28
	ØB	29.2	30.0	30.0	29.0	29.5	29	28
	ØC	28.8	29.5	29.5	29.0	29.5	29	28.5

CONCLUSIONS AND RECOMMENDATIONS

The electrical and mechanical design of Engineered Magnetics Model EMIU104D Static Inverter complies with, or exceeds, the specified design requirements. Redesign of the low level regulator may be required at a later date. During testing, Pesco Products observed that if the DC bus voltage is not applied as a step function, the inverter can turn on without the application of the turn on pulse. The source of this is located in the exponential time curve of the two internal time constant circuits (R27 and C7, and R28 and C6). These circuits are affected when subjected to a slow rise of input voltage. Under this condition, the leakage currents of Q8 and Q9 effect inverter operation to a greater extent than do the RC time constants.

The pulse turn on and/or turn off circuits can be reduced through the use of latching relays. This change will effect the inverter MTBF reliability calculation.

After completion of the test program at Pesco Products and NASA Lewis, more realistic system requirements will be known and a reduction in size, weight, and component part count can then be initiated.

APPENDIX I

DETAIL DESIGN, EMIU104D STATIC INVERTER

Electrical Schematic, Drawing No. 513634C

Outline and Specification, Drawing No. 413519A

Final Assembly, Drawing No. 514100B

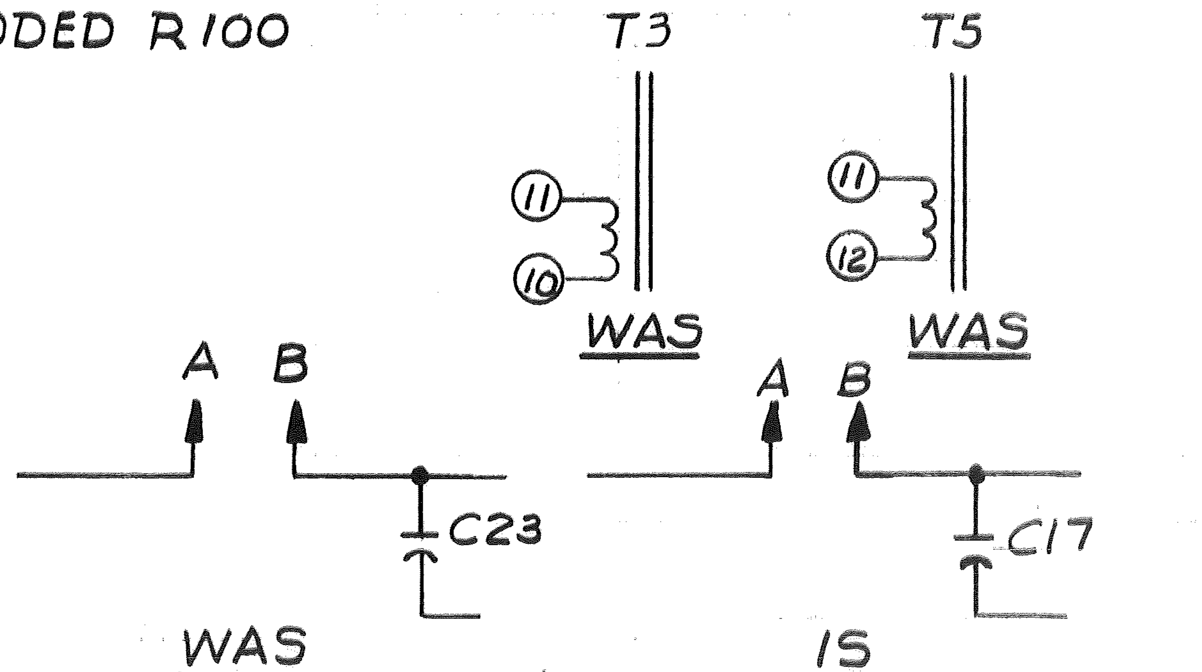
List of Materials, Drawing No. LM514100B

GULTON INDUSTRIES, INC. 19 HAWTHORNE, CALIFORNIA	CODE IDENT NO. **06509**	EO NO. 24689 ENGINEERING ORDER
		SHEET 1 OF 1 — REV
L/M NO. LM514100	DWG TITLE SCHEMATIC EMIU104D	DWG NO. 513634 — REV C
MODEL NO. EMIU104D		
DATE 19 AUG. 1968		INCORPORABLE: YES ✓ NO
REQD BY R. SIMONSON	OTHER DWGS AFFECTED ——	DEPT. AFFECTED
DR Yamanaka		PROTO: ✓ PROD: ✓
CHK Berriman. 8-22-68.		SPL PROD: WHT RM:
ENG	REASON: UPDATE DWG.	
MECH ENG		
REL ENG		
Q.C.	EFFECTIVITY (LIST JOB & SERIAL NO.): JOB NO. 6502 & FUTURE	
PROJ ENG		
PROD MGR		
APPD B J McCord	DISPOSITION OF MATL / PARTS: ——	
CUSTOMER APPD		

REVISION

CHANGE NOTICE

ADDED R100



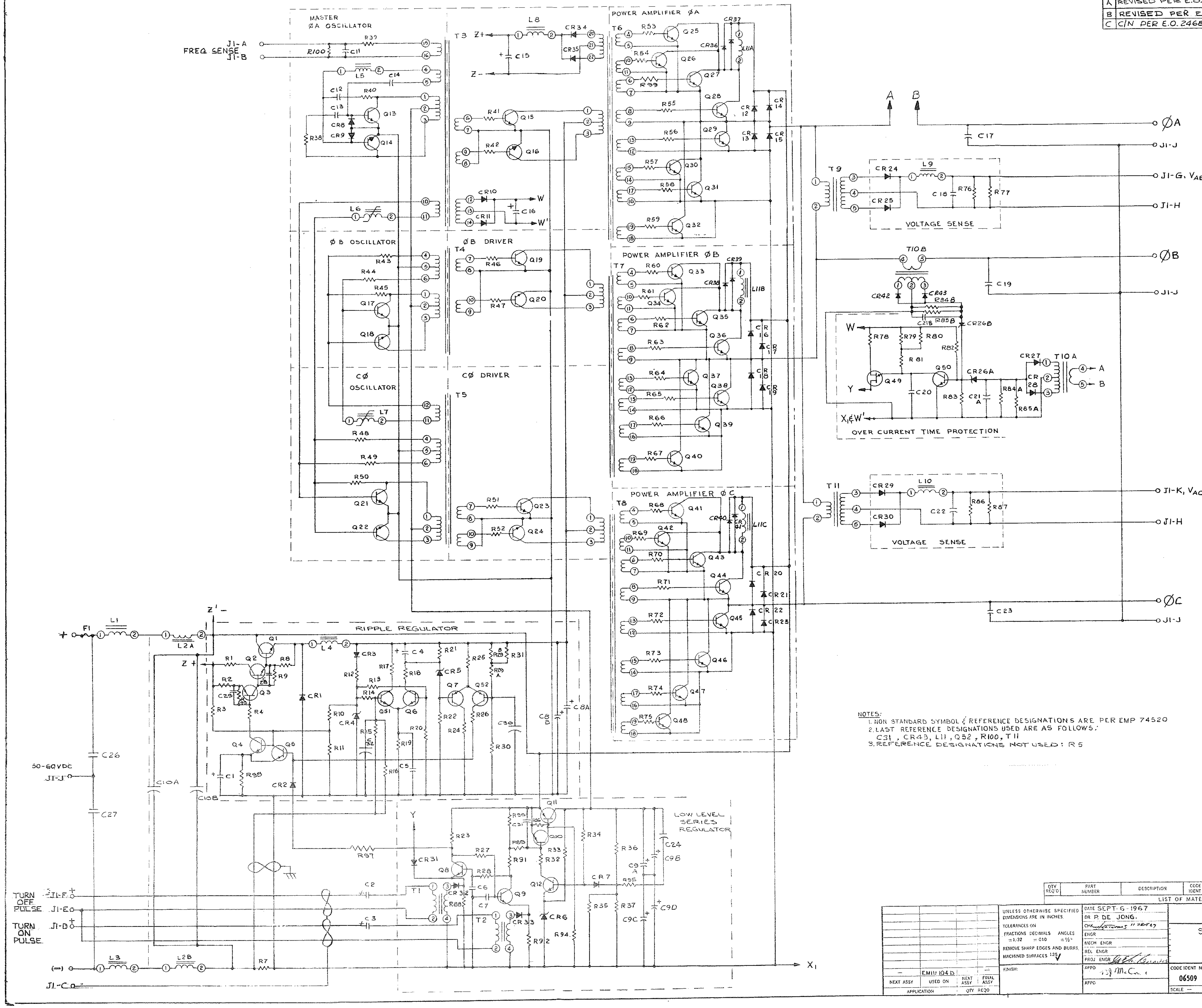
DIODE DESIGNATION F/D AT T10B CR42 WAS CR36
CR43 WAS CR37

NOTE 2. LAST REF DESIGNATION WAS CR37 & R97

DWG NO. 513634 C

INCORPORATED	DATE 19 AUG 68	DR Yamanaka	CHK E.J. BERRIMAN.

EM35923-1 FORM 303 REV. B



REVISIONS			
SYM	DESCRIPTION	DATE	APPROVED
A	REVISED PER E.O. 22907		
B	REVISED PER E.O. 23986		
C	C/N PER E.O. 24689	19 AUG 68	

NOTES:
1. NON STANDARD SYMBOL & REFERENCE DESIGNATIONS ARE PER EMP 74520
2. LAST REFERENCE DESIGNATIONS USED ARE AS FOLLOWS:
C31, CR43, L11, Q52, R100, T11
3. REFERENCE DESIGNATIONS NOT USED: R5

513634 C

QTY REQ'D	PART NUMBER	DESCRIPTION	CODE IDENT	SPECIFICATION	MATERIAL	ITEM NO.

LIST OF MATERIAL

NEXT ASSY	USED ON	NEXT ASSY	FINAL ASSY
—	EMIU 104 D		—

APPLICATION — QTY REQD

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES.
TOLERANCES ON FRACTIONS ±1/32, DECIMALS ±.010, ANGLES ±½°
REMOVE SHARP EDGES AND BURRS. MACHINED SURFACES 125√
FINISH:

DATE SEPT-6-1967
DR P. DE JONG.
CHK
ENGR
MECH ENGR
REL ENGR
PROJ ENGR
APPD
APPD

ENGINEERED MAGNETICS
DIVISION OF GULTON INDUSTRIES, INC.
HAWTHORNE, CALIFORNIA

SCHEMATIC DIAGRAM — STATIC INVERTER, EMIU 104 D

CODE IDENT NO. 06509 | SIZE E | 513634

SCALE — | SHEET 1 OF 1

GULTON INDUSTRIES, INC. HAWTHORNE, CALIFORNIA	CODE IDENT NO. 06509	EO NO. № 25117 ENGINEERING ORDER SHEET 1 OF 1	REV
L/M 514100	DWG TITLE	DWG NO. 514100	B
MODEL EMIU 104D	FINAL ASSY.	INCORPORABLE: YES ✓ NO __	
REQD BY H. TAMANAKA	OTHER DWGS AFFECTED	DEPT. AFFECTED	
DR E.J. BERRIMAN.	LM.	PROTO: ✓	PROD: ✓
CHK 31 DEC 68		SPL PROD:	WHT RM:
MECH	REASON: UPDATE DWG.		
DES ENG			
REL			
PROG MGR			
ENG MGR	EFFECTIVITY (LIST JOB & SERIAL NO.): JOB NO. 6502 & FUTURE		
QC			
APPD BJ Mc Conl	DISPOSITION OF MATL / PARTS: UNIT MUST CONFORM		
CUSTOMER APPD			

REVISION

CHANGE NOTICE.

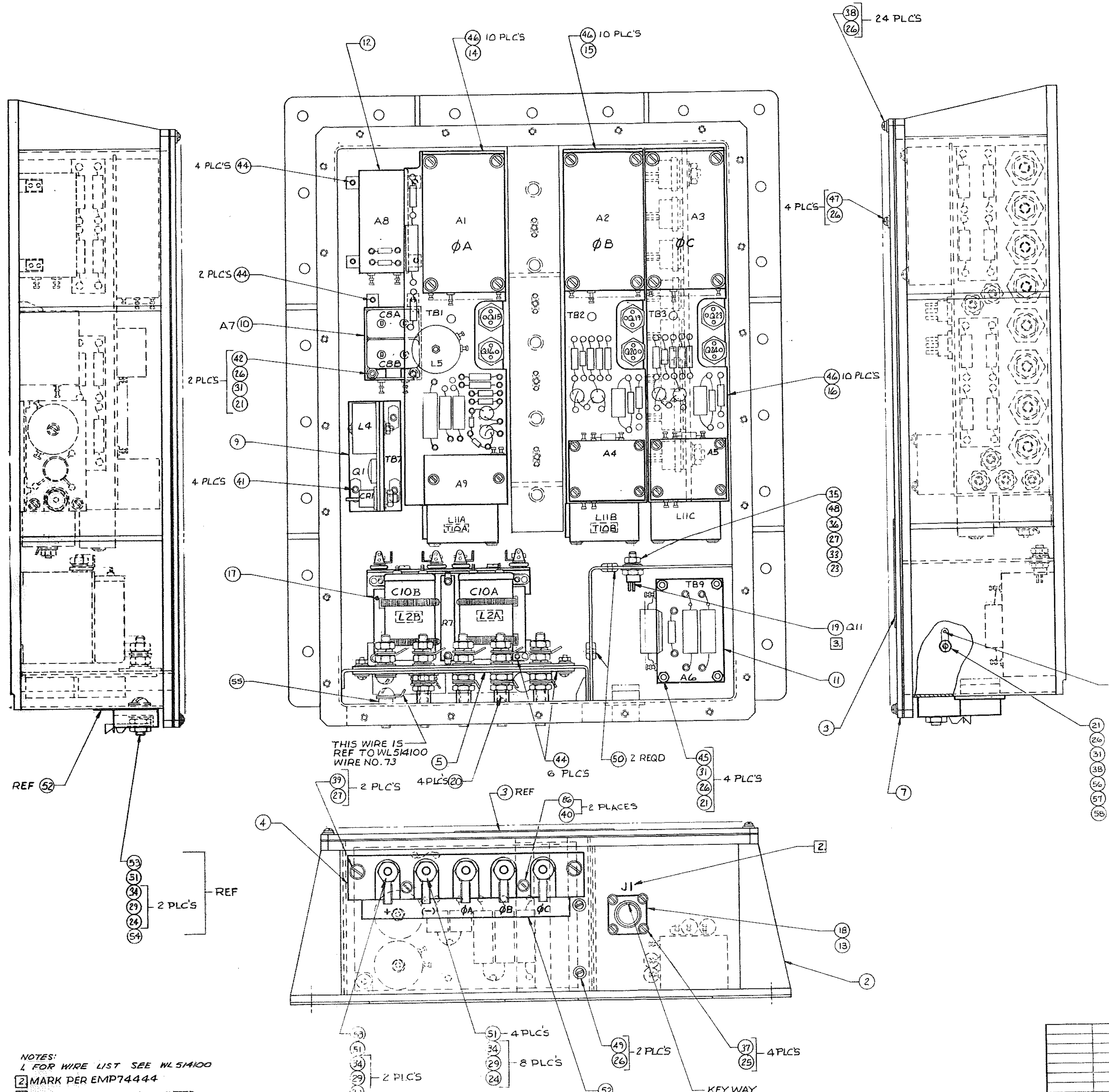
1. ON F/D ADDED ITEM: 55 & ON R.H. VIEW ADDED LUG WITH HARDWARE ITEMS 21, 26, 31, 38, 56, 57 & 58
2. CAPACITORS WERE SHOWN C10B, L2B, R.H & C10A, L2A, L.H.
3. ON LM ITEM: 21 WAS 6 REQ'D
   26 | 38 |
   31 | 6 REQ'D
   ITEM: 38 WAS MS 51957-29, #6-32 X 7/16, 24 REQ'D
   ITEM: 53 WAS MS 35230-83, #1/4-28 X 1"
   ITEMS 55-58 ADDED

DWG NO. 514100 B

INCORPORATED	DATE 12-30-68.	DR E.J. BERRIMAN.	CHK H.T.

FM 35923-1 FORM 303 REV C

REVISIONS			
SYM	DESCRIPTION	DATE	APPROVED
A	C/N PER E.O. 24706 #2	26 AUG 68	
B	C/N PER EO. 25117 E.J.B.	12-30-68.	



NOTES:
1. FOR WIRE LIST SEE WL 514100
2. MARK PER EMP74444
3. TSTR ITEM: 19 TO BE MOUNTED PER EMP 74447
4. WORKMANSHIP TO BE PER 79400

2	14092-3	WASHER, FLT. INS				58
1	25429-2	INSERT, INS				57
1	110X .144	LUG			ZIERICK	56
1	3/8 O.D X .281 I.D X .125	TUBE		EPOXY GLASS LAMINATE	NEMA G10	55
1	127-.281	LUG			ZIERICK	54
1	MS35230-84	SCREW, PAN HD		#1/4-28X1 1/4	BRASS	53
1	313559	IDENT. PLATE				52
5	208-.250	LUG			ZIERICK	51
2	MS35489-4	GROMMET				50
2	MS51957-27	SCREW, PAN HD		#6-32X5/16		49
1	25429-3-3	INSERT		#8		48
4	MS51957-31	SCREW, PAN HD		#6-32X5/8		47
30	MS24693C-274	SCREW, C'SK		#10-32X3/4		46
4	-40	, C'SK		#6-32X2		45
12	-28	, C'SK		#6-32X1/2		44
						43
2	-42	, C'SK		#6-32X2 1/2		42
4	MS24693C-29	, C'SK		#6-32X5/8		41
2	MS35233-33	, PAN HD		#6-32X7/8		40
2	MS51957-49	, PAN HD		#8-32X1		39
25	MS51957-30	, PAN HD		#6-32X1/2		38
4	MS51957-15	SCREW, PAN HD		#4-40X3/8		37
1	14092-4	WASHER, EPOXY		#8		36
1	1747-2	, MICA		#8		35
10	AN935B416	, LOCK		1/4	BRONZE	34
1	MS35338-80	, LOCK		#8		33
						32
7	MS35338-79	, LOCK		#6		31
						30
10	AN961-416	, FLT		1/4	BRASS	29
						28
3	MS15795-807	, FLT		#8		27
39	-805	, FLT		#6		26
4	MS15795-803	WASHER, FLT		#4		25
10	AN345B416	NUT, HEX		1/4-28	BRASS	24
1	MS35649-84	, HEX		#8-32		23
						22
7	MS35649-64	NUT, HEX		#6-32		21
4	14101-5C12	SPACER				20
1	2N5001	TSTR	Q11		FAIRCHILD	19
1	MS3112E-12-10S	CONNECTOR	J1		MIL-C-26482	18
1	313496	FILTER ASSY	FL1			17
1	414118	PHASE C ASSY				16
1	414114	PHASE B ASSY				15
1	414111	PHASE A ASSY				14
2	MS3116E-12-10P	PLUG			MIL-C-26482	13
1	314182	MODULE ASSY	A8			12
1	314155	COMP ASSY	A6			11

514100 B

QTY REQ'D	PART NUMBER	DESCRIPTION	CODE IDENT	SPECIFICATION	MATERIAL	ITEM NO.
1	314164	CAP. MT. ASSY	A7			10
1	314161	HEAT SINK ASSY	TB7			9
						8
1	414102	COVER PLATE & GASKET ASSY				7
						6
1	314149	RFI ASSY				5
1	314177	INSULATOR BKT				4
1	31350[illegible]	NAMEPLATE				3
1	514101	CASE ASSY				2
	-1	ASSEMBLY				1

LIST OF MATERIAL

NEXT ASSY	USED ON	NEXT ASSY	FINAL ASSY
—	EMIU104D	—	—
APPLICATION		QTY REQD	

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES.
TOLERANCES ON
FRACTIONS ±1/32 DECIMALS ±.010 ANGLES ±1/2°
REMOVE SHARP EDGES AND BURRS.
MACHINED SURFACES 125 √
FINISH:

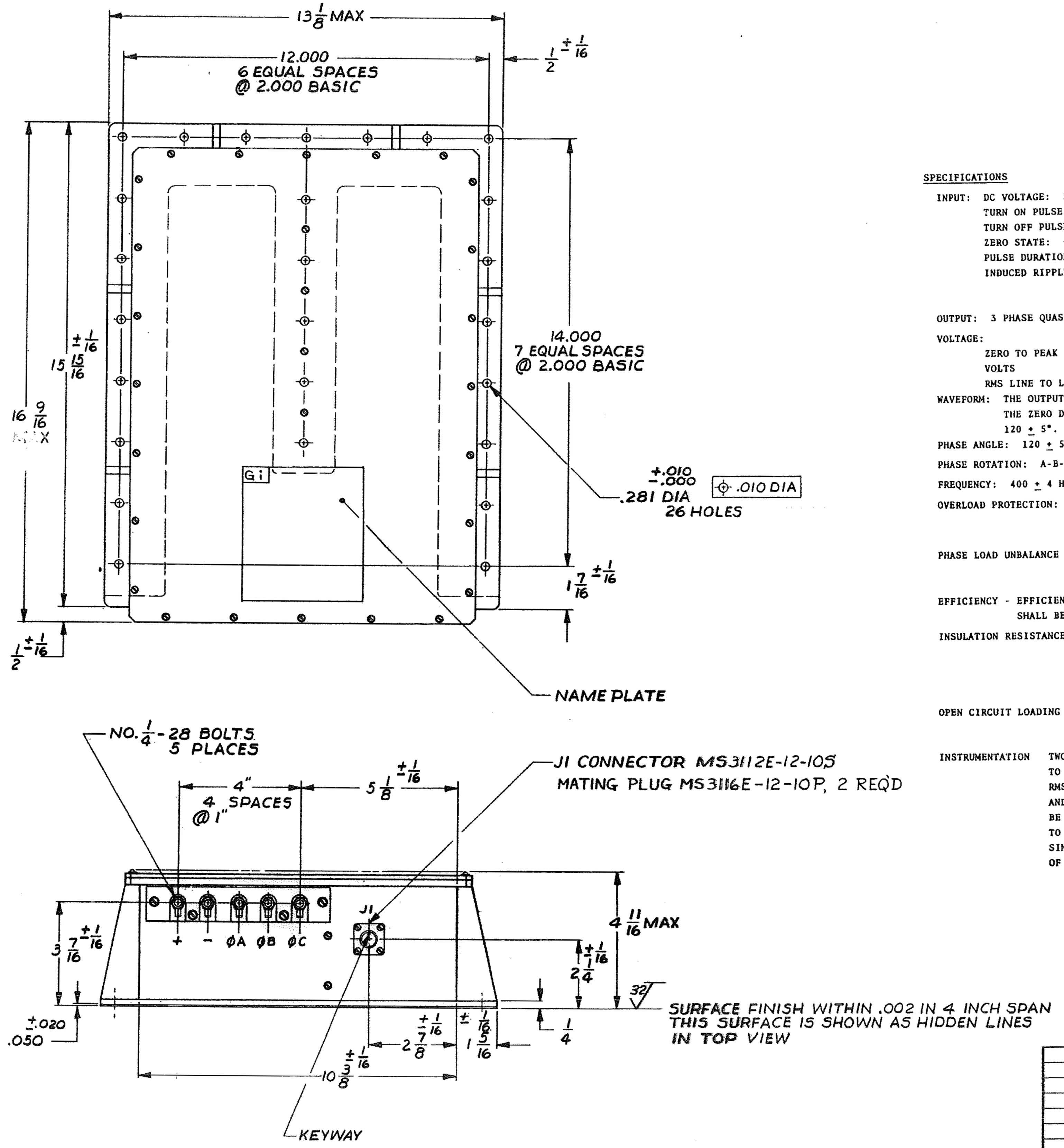
DATE 25 MARCH 68
DR
CHK 5-31-68.
ENGR
MECH ENGR
REL ENGR
PROJ ENGR
APPD
APPD

ENGINEERED MAGNETICS
DIVISION OF GULTON INDUSTRIES, INC.
HAWTHORNE, CALIFORNIA

FINAL ASSEMBLY
EMIU104D

CODE IDENT NO. 06509 SIZE E 514100 B
SCALE 1/1 SHEET 1 OF 1

SYM	DESCRIPTION	DATE	APPROVED
A	REVISED & REDRAWN H.T.		



SPECIFICATIONS

INPUT: DC VOLTAGE: 50 TO 60 VOLTS
TURN ON PULSE: +2.4 TO +5.0 VOLTS
TURN OFF PULSE: +2.4 TO +5.0 VOLTS
ZERO STATE: +0.22 VOLTS
PULSE DURATION: 3.0 MILLISECONDS MINUMUM
INDUCED RIPPLE: 3.6 AMPERES RMS
WITH A DC SOURCE IMPEDANCE OF
0.06 OHMS AT RUNNING LOAD.

OUTPUT: 3 PHASE QUASI-SQUARE WAVE

VOLTAGE:
ZERO TO PEAK LINE TO LINE IS APPROXIMATELY E_{DC} INPUT LESS 1.5 VOLTS
RMS LINE TO LINE IS APPROXIMATELY 0.816 TIMES V_{O-P}

WAVEFORM: THE OUTPUT VOLTAGE IS QUASI-SQUARE VOLTAGE.
THE ZERO DWELL SHALL BE 60 ± 5° AND THE PEAKS 120 ± 5°.

PHASE ANGLE: 120 ± 5°

PHASE ROTATION: A-B-C

FREQUENCY: 400 ± 4 Hz

OVERLOAD PROTECTION: THE OVERLOAD PROTECTION SHALL OPERATE WITHIN 5 ± 0.5 SECONDS AFTER THE STARTING LOAD IS APPLIED.

PHASE LOAD UNBALANCE - THE LOAD (INDUCTION MOTOR) WILL BE BALANCED WITHIN 10 PER CENT IMPEDANCE PER PHASE. NO SINGLE PHASE LOADS WILL BE APPLIED.

EFFICIENCY - EFFICIENCY AT RATED INPUT VOLTAGE AND FULL MOTOR LOAD SHALL BE NOT LESS THAN 85 PER CENT, AS A DESIGN OBJECTIVE.

INSULATION RESISTANCE - THE STATIC INVERTER SHALL EXHIBIT INSULATION RESISTANCE IN EXCESS OF 20 MEGOHMS, AT 100 PLUS OR MINUS 10 VOLTS DC, BETWEEN ANY TERMINAL OR COMPONENT TO CASE WITH THE FOLLOWING EXCEPTION: AFTER EXPOSURE TO HUMIDITY, THE INSULATION RESISTANCE REQUIREMENTS SHALL BE REDUCED TO 5 MEGOHMS.

OPEN CIRCUIT LOADING - THE STATIC INVERTER SHALL BE CAPABLE OF HAVING ITS LOAD REMOVED WHILE POWER IS APPLIED TO THE INPUT OF THE INVERTER WITHOUT DETERMENTAL EFFECTS ON THE INVERTER.

INSTRUMENTATION TWO OF THE PHASE VOLTAGES SHALL BE TRANSFORMER ISOLATED AND CONVERTED TO A DC SINGLE (PLUS OR MINUS 10 PER CENT), PROPORTIONAL TO THE RMS OUTPUT VOLTAGE. THE OUTPUT IMPEDANCE SHALL BE 1K OHMS MAXIMUM, AND THE LOAD RESISTANCE SHALL BE 100K OHMS MINIMUM. THE RIPPLE VOLTAGE SHALL BE 5 MV RMS MAXIMUM. THE MASTER OSCILLATOR FREQUENCY SHALL BE CONVETTED TO A 6.25 (PLUS 1.400 MINUS 0.000) VOLT PEAK-TO-PEAK AC SQUARE WAVE SINGLE AT THE NOMINAL FREQUENCY OF 400 HERTZ. THE CIRCUIT SHALL BE CAPABLE OF DRIVING A NOMINAL IMPEDANCE OF 10K OHMS.

413519 A

QTY. REQ'D	PART NUMBER	DESCRIPTION	CODE IDENT	SPECIFICATION	MATERIAL	ITEM NO.

LIST OF MATERIAL

NEXT ASSY	USED ON	NEXT ASSY	FINAL ASSY
—	EMIU104D	—	—
APPLICATION		QTY REQD	

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES.
TOLERANCES ON
FRACTIONS ±1/32 DECIMALS ±.010 ANGLES ±½°
REMOVE SHARP EDGES AND BURRS.
MACHINED SURFACES 125

FINISH: ALODINE 1200 PER MIL-C-5541

DATE 7 MAR. 1968
DR Yamanaka
CHK 5-29-68
ENGR
MECH ENGR
REL ENGR
PROJ ENGR
APPD
APPD

Gulton Industries, Inc.
HAWTHORNE, CALIFORNIA

OUTLINE & SPECIFICATION
STATIC INVERTER
EMIU104D

CODE IDENT NO. 06509 | SIZE D | 413519
SCALE 1/2 | SHEET 1 OF 1

GULTON INDUSTRIES, INC. HAWTHORNE, CALIFORNIA	CODE IDENT NO. **06509**	EO NO. № 26196 ENGINEERING ORDER

SHEET 1 OF 1

L/M LM514100	DWG TITLE	DWG NO. LM514100 (REV B); ~~314109~~ (REV ~~A~~)
MODEL IU104D	LIST OF MATERIALS COMPONENT ASSY	INCORPORABLE: YES X NO __
REQD BY H. TAMANAKA		
DR K. JACOBS	OTHER DWGS AFFECTED: NONE	DEPT. AFFECTED — PROTO: / PROD: ✓ / SPL PROD: / WHT RM:
CHK		
MECH		
DES ENG	REASON: DRAFTING ERROR - 2 R99 EXIST	
REL		
PROG MGR		
ENG MGR	EFFECTIVITY (LIST JOB & SERIAL NO.): JOB 6502 & FUTURE	
QC		
APPD	DISPOSITION OF MATL / PARTS: NOT AFFECTED	
CUSTOMER APPD		

REVISION

LM514100

1. ITEM 531 - CHG REF DES'G FROM R99 TO R100

314109

2. ITEM 17 & ON ASSY VIEW - CHANGE REF DESIG FROM R99 TO R100.

DWG NO. LM514100 B; ~~314109~~ ~~A~~

INCORPORATED	DATE	DR	CHK

EM35923-1 FORM 303 REV C

GULTON INDUSTRIES, INC. HAWTHORNE, CALIFORNIA	CODE IDENT NO. 06509	EO NO. № 25118 ENGINEERING ORDER	
		SHEET 1 OF 1	REV
L/M 514100	DWG TITLE LIST OF MATERIALS	DWG NO. LM514100	B
MODEL EMIU104D			
REQD BY H. TAMANAKA		INCORPORABLE: YES ✓ NO	
DR E.J. BERRIMAN.	OTHER DWGS AFFECTED 514100	DEPT. AFFECTED	
CHK		PROTO: ✓	PROD: ✓
MECH		SPL PROD:	WHT RM:
DES ENG	REASON: UPDATE LM.		
REL			
PROG MGR			
ENG MGR	EFFECTIVITY (LIST JOB & SERIAL NO.): JOB NO. 6502 & FUTURE		
QC			
APPD BJ McComb	DISPOSITION OF MATL / PARTS: UNIT MUST CONFORM		
CUSTOMER APPD			

REVISION

CHANGE NOTICE.

1. ITEM: 51 WAS 6 REQ'D
2. ITEM: 58 WAS 38 REQ'D
3. ITEM: 66 WAS 6 REQ'D
4. ITEM: 79 WAS MS51957-29, #6-32 X 7/16, 24 REQ'D
5. ITEM: 100 WAS MS 35230-83, 1/4-28 X 1"
6. ADDED ITEMS 102-105

DWG NO. LM514100 B

INCORPORATED	DATE 12-30-68.	DR E.J. BERRIMAN	CHK

FM35923-1 FORM 303 REV C

REVISIONS

SYM	DESCRIPTION	DATE	APPROVED
A	C/N PER E.O. 24691 A 2	20 AUG.68	[illegible]
B	C/N PER E.O. 25118 E.J.B.	12-30-68.	[illegible]

DATE 8 APRIL 68	**Gulton Industries, Inc.** HAWTHORNE, CALIFORNIA
DR John M. [illegible]	
CHK [illegible] 6-4-68.	LIST OF MATERIALS EMIU104D
ENGR	
MECH ENGR [illegible] 6/4/68	
REL ENGR	
PROJ ENGR [illegible]	
APPD BJ McComb	CODE IDENT NO. 06509 · SIZE A · LM514100 · B
APPD	SCALE —— · SHEET 1 OF 22

ITEM	PART NUMBER	ASSY LEVEL 1 2 3 4 5 6	DESCRIPTION, SYM, SPEC, CODE IDENT NO.	QTY REQ
1	413519		OUTLINE & SPEC DWG	
2				
3	513634		SCHEMATIC	
4				
5	710410		RIVET INSTALLATION	
6	72378		WELDING MANUAL	
7	EMP74444		IDENT & MARKING PARTS & ASSEMBLIES	
8	EMP77430		PROCESS SPEC COATING & ADHESIVES	
9	EMP77431		PROCESS SPEC EPOCAST 202	
10	EMP 74960		MFR OF WINDINGS	
11	EMP77433		MFG PROCESS & PROCEDURE	
12			"C" CORE WINDINGS	
13	77918		PROC SPEC MATL LEAD	
14			COMPONENT PARTS	
15	79400		WORKMANSHIP STDS	
16	79492		HAND SOLDERING ELECT	
17			CONNECTIONS	
18				
19	EMP74447		METHODS OF MTG.	
20			SEMICONDUCTORS	
21	T413059		WELDING FIXTURE	
22	EMP711304		MTG SEMICONDUCTORS	
23			(FLATPACKS)	
24				
25	EMP712744		POTTING SPEC, SILICONE RUBBER	
26				
27	EMP 11019		POTTING SPEC, FLEXIBLE EPOXY RESIN	
28				
29	EMP 74448		PROCESS SPEC, IDENT PLATES	
30				
31	711488		CORES, PERMALLOY TYPE POWDER	
32	75908		PROC SPEC RES	
33	75574		PROC SPEC TOROIDAL CORES	
34	711476		SPEC CONTROL DWG, CAP	
35	710465		SPEC CONTROL DWG, RES	

SIZE	CODE IDENT NO	
A	06509	LM 514100
SCALE	REV B	SHEET 2

EM FORM 17759C

ITEM	PART NUMBER	ASSY LEVEL 1 2 3 4 5 6	DESCRIPTION SYM, SPEC, CODE IDENT NO.	QTY REQ
36	514100	\	FINAL ASSY	1
37	A313561	\	SILKSCREEN, NAMEPLATE	1
38	314177	\	INSULATOR BKT	1
39	414102	\	COVER PLATE &	1
40			GASKET ASSY	
41				
42				
43	MS3116E-12-10P	\	PLUG MIL-C-26482	2
44	MS3112E-12-10S	\	CONNECTOR J1, MIL-C-26482	1
45	2N5001	\	TSTR Q11 FAIRCHILD	1
46	14101-5C12	\	SPACER	4
47				
48				
49				
50				
51	MS35649-64	\	NUT, HEX #6-32	7
52				
53	MS35649-84	\	, HEX #8-32	1
54	AN345B416	\	NUT, HEX 1/4-28 BRASS	10
55				
56				
57	MS15795-803	\	WASHER, FLT #4	4
58	-805	\	, FLT #6	39
59	MS15795-807	\	WASHER, FLT #8	3
60				
61	AN961-416	\	WASHER, FLT 1/4 BRASS	10
62				
63				
64				
65	MS35338-78	\	WASHER, LOCK #4	1
66	-79	\	, LOCK #6	7
67				
68	MS35338-80	\	, LOCK #8	1
69	AN935B416	\	WASHER, LOCK 1/4 BRONZE	10
70				

SIZE	CODE IDENT NO	
A	06509	LM 514100
SCALE ———	REV B	SHEET 3

EM FORM 17759C

ITEM	PART NUMBER	ASSY LEVEL 1 2 3 4 5 6	DESCRIPTION, SYM, SPEC, CODE IDENT NO.	QTY REQ
71	313559	\	IDENTIFICATION PLATE	1
72	A313560	\	SILKSCREEN	1
73				
74	1747-2	\	WASHER, MICA #8	1
75	14092-4	\	WASHER, EPOXY #8	1
76				
77	MS 51957-31	\	SCREW, PAN HD #6-32X5/8	4
78	MS 51957-15	\	SCREW, PAN HD #4-40X3/8	4
79	MS51957-30	\	SCREW, PAN HD #6-32X 1/2	25
80	MS51957-49	\	SCREW, PAN HD #8-32X 1	2
81	MS 51957-27	\	SCREW, PAN HD #6-32X 5/16	2
82	MS 35233-33	\	SCREW, PAN HD #6-32X7/8	2
83	MS24693C-29	\	SCREW, C'SK #6-32X 5/8	4
84				
85	-42	\	, C'SK #6-32X 2 1/2	2
86				
87	-28	\	, C'SK #6-32X 1/2	12
88	-40	\	, C'SK #6-32X 2	4
89	MS24693C-274	\	SCREW C'SK #10-32X 3/4	30
90				
91				
92				
93	25429-3-3	\	INSERT #8	1
94				
95				
96	MS35489-4	\	GROMMET	2
97				
98	208-.250	\	LUG ZIERICK	5
99	127-.281	\	LUG ZIERICK	1
100	MS35230-84	\	SCREW, PAN HD. 1/4-28X1 1/4 BRASS	1
101				
102	3/8 O.D.X.281 I.D X.125	\	TUBE EPOXY GL. LAM. NEMA G10	1
103	110X.144	\	LUG ZIERICK	1
104	25429-2	\	INSERT, INS	1
105	14092-3	\	WASHER, FLT. INS	2

SIZE	CODE IDENT NO	
A	06509	LM 514100
SCALE ——	REV B	SHEET 4

ITEM	PART NUMBER	ASSY LEVEL 1	2	3	4	5	6	DESCRIPTION, SYM, SPEC, CODE IDENT NO.	QTY REQ
106									
107									
108									
109									
110									
111									
112	314161		\					HEAT SINK ASSY, TB7	1
113	314152			\				TERM BD ASSY TB7	1
114	4535-A				\			TERMINAL LERCO	3
115	314138			\				CHOKE L4	1
116	214618				\			POTTING CUP	1
117	33449BC13-0					\		CUP	1
118	5026-A					\		TERMINAL LERCO	2
119	55930-W4				\			CORE MAG. INC.	1
120	74808H			\				DIODE CR1	1
121	711347H			\				TRANSISTOR Q1	1
122	MS35233-15			\				SCREW, P. H. #4-40	2
123	27999C0421			\				SCREW, P. H. #4-40	1
124	MS35649-104			\				NUT, HEX #10-32	1
125	MS35649-44			\				NUT, HEX #4-40	3
126	NAS620-A4L			\				WASHER, FLT #4	6
127	MS15795-808			\				WASHER, FLT #10	1
128	MS35337-78			\				WASHER, LOCK #4	3
129	MS35337-81			\				WASHER, LOCK #10	1
130									
131	25429-4-7			\				INSERT	1
132	314153			\				HEAT SINK	1
133	MK2331-06				\			NUT ANCHOR #6-32 KAYLOCK	1
134	MF1001-06				\			NUT ANCHOR #6-32 KAYLOCK	3
135	MS20426AD2				\			RIVET	2
136	MS20426AD3				\			RIVET	6
137	BBD-625-063			\				HEAT SINK, INS NAT. BERYLLIA CO.	1
138									
139	TYPE E			\				WIRE FLEX MIL-W-16878 TEFLON	A/R
140									

SIZE	CODE IDENT NO	
A	06509	LM 514100
SCALE —	REV B	SHEET 5

EM FORM 17759C

ITEM	PART NUMBER	ASSY LEVEL 1 2 3 4 5 6	DESCRIPTION, SYM, SPEC, CODE IDENT NO.	QTY REQ
141	514101	2	CASE ASSY	1
142	MT2S632K	3	NUTPLATE BOOTS AIRCRAFT	4
143	KNHL0632	3	INSERT KEENSERT	24
144	MS20426AD2	3	RIVET	16
145	MS20426AD3	3	RIVET	8
146	MF1001-08	3	NUTPLATE KAYNAR	2
147	MF1301-04	3	NUTPLATE KAYNAR	4
148	MK2001-06	3	NUTPLATE KAYNAR	2
149				
150				
151				
152	314164	2	CAPACITOR MOUNT - A7 ASSY	1
153	214165	3	CUP ASSY	1
154	3010B	4	TERMINAL LERCO	2
155	MF6001-06	4	NUTPLATE KAYNAR	2
156	MS20426AD3	4	RIVET	4
157	75576-4	3	CAPACITOR C8A & B	2
158	771	3	CLAMP HERMAN H. SMITH	2
159				
160				
161				
162	314155	2	COMPONENT ASSY, A6	1
163	214151	3	TERMINAL BD, TB9	1
164	3050-B	4	TERMINAL LERCO	6
165	214154	3	MODULE, POTTED A6	1
166	314150	4	CUP ASSY	1
167	3050-B	5	TERMINAL LERCO	11
168	214157	4	MODULE	1
169	314123	5	TRANS. T1, T2	1
170	A13A1	6	CORE EM75574	1
171	414156	5	MODULE ASSY, LOW LEVEL A6	1
172	A414156-2	6	POSITIONER (ARTWORK)	1
173	A414156-3	6	POSITIONER (ARTWORK)	1
174				
175				

SIZE	CODE IDENT NO	
A	06509	LM 514100
SCALE ———	REV B	SHEET 6

ITEM	PART NUMBER	ASSY LEVEL 1	2	3	4	5	6	DESCRIPTION, SYM, SPEC, CODE IDENT NO.	QTY REQ
176									
177	M39003/01-2049						\	CAP C2, C3 15 µf 20 VDC	2
178								MIL-C-39003	
179	CYK01BT682K						\	CAP C6 .0068µf@50 VDC	1
180								PER 711476	
181	CYK01BT472K						\	CAP C7 .0047µf@50 VDC	1
182								PER 711476	
183	LP8A1B224K						\	CAP C24 0.22 µF @ 100VDC	1
184								DEARBORN	
185	CYK01BV223K						\	CAP C31 0.022µF PER 711476	1
186	AF1N645						\	DIODE CR7, 31A, 32, 33 MIL-E-1/1143	4
187	79430H						\	DIODE CR6A	1
188	RN55C5112F						\	RES R23 51.1K 710465	1
189	RN60C2493F						\	R27 249K 75908	1
190	RN60C3013F						\	R28 301K 75908	1
191	RN55C4221F						\	R32 4.22K 710465	1
192	RS-2 – 20KΩ						\	R33 20KΩ DALE	1
193	RN60C1003F						\	R34 100K 75908	1
194	RN60C3012F						\	R36 30.1K 75908	1
195	RN55C5361F						\	R37 5.36K 710465	1
196	RN55C3000F						\	R88, 92 300Ω 710465	2
197	WWA-13-18-5K						\	R89 5K BALCO	1
198	RN55C4421F						\	R90 4.42 K 710465	1
199	RN55C4642F						\	R91 46.4K 710465	1
200	RW79U4001F						\	R94 4K MIL-R-26	1
201	RN55C8660F						\	R95 866Ω 710465	1
202	RN55C3011F						\	R96 3.01KΩ 710465	1
203	RN60C1963F						\	RES R97 196K 75908	1
204	73531H						\	TSTR Q8, 9, 12	3
205	711477H						\	TSTR Q10	1
206	77977						\	RIBBON, NICKEL .030 X .010	A/R
207	77976						\	WIRE, NICKEL .020 DIA	A/R
208	TYPE E					\		WIRE FLEX MIL-W-16878 TEFLON	A/R
209									
210									

SIZE	CODE IDENT NO	
A	06509	LM 514100
SCALE ——	REV B	SHEET 7

ITEM	PART NUMBER	ASSY LEVEL 1 2 3 4 5 6	DESCRIPTION, SYM, SPEC, CODE IDENT NO.	QTY REQ
211				
	EM79474-6		CAP C9A,B,C,D 30 µF, 75VDC G.E.	4
	RN55C . . . F *		RES. R35 * SET IN TEST 710465	1
215	TYPE E		WIRE, FLEX MIL-W-16878 TEFLON	A/R
	TYPE S		WIRE, BUSS QQ-W-343	A/R
			SOFT COAT	
220				
225				
	314182		MODULE ASSY A8	1
	314168		CUP ASSY, A8	1
	3050-B		TERMINAL LERCO	10
230	MF6001-06		NUTPLATE KAYNAR	4
	MS20426AD3		RIVET	8
	414184		MODULE COMPONENT ASSY	1
	A414184-2		POSITIONER (ARTWORK)	1
	A414184-3		POSITIONER (ARTWORK)	1
235	M39003/01-2064		CAP C1,4,5 6.8 µF @ 35 VDC MIL-C-39003	3
	CYK01BT332K		CAP C29, 30 0.0033 µF 711476	2
	CYK01BV223K		CAP C28 0.022 µF 711476	1
	39003/01-2043		CAP C32, 2.2 µf, 20VDC MIL-C-39003	1
	AF1N645		DIODE CR2, CR3 MIL-E-1/1143	2
240	79430H		DIODE CR4, CR5	2
	RW79U3R01F		RES R1 3 Ω MIL-R-26	1
	RW79U12R4F		R2 12.5 Ω MIL-R-26	1
	RN55C7152F		R3 71.5 KΩ 710465	1
	RN55C1782F		R4 17.8 KΩ 710465	1
245	RN55C1000F		RES R8 100 Ω 710465	1

SIZE	CODE IDENT NO	
A	06509	LM 514100
SCALE ——	REV B	SHEET 8

ITEM	PART NUMBER	ASSY LEVEL 1 2 3 4 5 6	DESCRIPTION, SYM, SPEC, CODE IDENT NO.	QTY REQ
246	RN55C5110F		RES R9 511Ω 710465	1
	RN55C2151F		R10 2.15KΩ 710465	1
	RN55C3651F		R11 3.65KΩ 710465	1
	RW74U4991F		R12 5KΩ MIL-R-26	1
250	RN55C2871F		R13 2.87KΩ 710465	1
	2151F		R14 2.15KΩ 710465	1
	2051F		R15 2.05KΩ 710465	1
	5621F		R17 5.62KΩ 710465	1
	2151F		R18 2.15KΩ 710465	1
255	5360F		R19 536Ω 710465	1
	RN55C1781F		R20 1.78KΩ 710465	1
	RW79U8500F		R21 850Ω MIL-R-26	1
	RW74U6491F		R22 6.5KΩ MIL-R-26	1
	RN55C2492F		R24 24.9KΩ 710465	1
260	2742F		R25 27.4KΩ 710465	1
	6192F		R26 61.9KΩ 710465	1
	3652F		R29B 36.5KΩ 710465	1
	8252F		R30 82.5KΩ 710465	1
	RN55C2151F		R93 2.15K 710465	1
265	RN55C1211F		RES R98 1.21K 710465	1
	711477H		TSTR Q3,7,52 2N3635	3
	WWA-13-18-1.5K		RES R29A BALCO	1
	73531H		TSTR Q4-6,51 2N2102	4
270	78324H		TSTR Q2 2N2658	1
	RN55C___F ✱		RES R31, R16 ✱ S.I.T. 710465	2
275				
280				

SIZE	CODE IDENT NO	
A	06509	LM 514100
SCALE —	REV B	SHEET 9

ITEM	PART NUMBER	ASSY LEVEL (1 2 3 4 5 6)	DESCRIPTION, SYM, SPEC, CODE IDENT NO.	QTY REQ
281	414114	2	PHASE B ASSY	1
285	313557	3	TRANSFORMER T10B	1
	AF1N645	4	DIODE CR42,43	2
	313555-1	4	POTTING CUP ASSY	1
	313555-2	5	CUP	1
290	5026-A	5	TERMINAL LERCO	4
	14101-4A28	5	TUBE	1
	314133	4	XMFR T10B	1
	A22A1	5	CORE EM75574	1
295	#2538	5	TAPE 3M	A/R
	414104	3	HEAT SINK, TSTR MT	1
	10140-2402	4	H-BEAM TIERNEY METALS	1
	MF1001-3	4	NUT PLATE #10-32 KAYNAR	10
300	MF1001-06	4	NUT PLATE #6-32 KAYNAR	2
	MS20426AD3	4	RIVET	36
	NCN-4-6-2	4	CAPTIVE NUT #4-40 NATIONAL RADIO CO.	2
	MF1001-08	4	NUT PLATE #8-32 KAYNAR	2
	MK2001-06	4	NUT, ANCHOR #6-32 KAYNAR	2
305	MK2001-08	4	NUT, ANCHOR #8-32 KAYNAR	2
	314175	3	COMP BD ASSY, TB2	1
	314173	4	TERM. BD ASSY TB2	1
	3025A	5	TERMINAL LERCO	17
	RW-79U34R8F	4	RES R43,44 34.8Ω MIL-R-26	2
310	RW-79U20R0F	4	R46,47 20Ω	2
	RW-79U1501F	4	R76 1500Ω	1
	RW-79U____F*	4	RES R77*S.I.T. MIL-R-26	1
	M39003/01-2023	4	CAP C18 120 μF @ 10VDC MIL-C-39003	1
	73531H-120	4	TSTR Q17,18	2
315	10038	4	TRANSIPAD MILTON ROSS	2

SIZE	CODE IDENT NO	
A	06509	LM 514100
SCALE ——	REV B	SHEET 10

ITEM	PART NUMBER	ASSY LEVEL 1	2	3	4	5	6	DESCRIPTION, SYM, SPEC, CODE IDENT NO.	QTY REQ
316	RN55C5112F				\			RES R45 51.1KΩ 710465	1
	3009-A					\		TERMINAL LERCO	1
	314113			\				CUP ASSY A2	1
	314172				\			POTTING CUP	1
320	3520-B					\		TERMINAL LERCO	2
	5026-B					\		TERMINAL LERCO	26
	314126				\			TRANSFORMER T4	1
	A20A1					\		CORE EM75574	1
	314129				\			TRANSFORMER T7	1
325	52038-2A					\		CORE MAG INC	1
	1747-1			\				WASHER, MICA	2
	25429-4-3			\				INSERT, INS	1
	NAS671-C10			\				NUT #10-32	6
330									
	214149			\				TERM BD TB5A & 5B	2
	3010A				\			TERMINAL LERCO	8
335									
	RW74UR750F			\				RES. R60-67 MIL-R-26	8
	JAN1N1202			\				DIODE, CR16-19, 38, 39 MIL-S-19500/260	6
	79807H			\				TSTR Q33-40	8
	MS35691-530			\				NUT, HEX 5/16-24	8
340	MS35691-430			\				NUT, HEX 1/4-28	2
	AN345B10			\				NUT, HEX BRASS	1
	1747-2			\				WASHER, MICA #10	6
	MS15795-812			\				WASHER, FLT 5/16	8
	MS15795-810			\				, FLT 1/4	2
345	MS15795-808			\				, FLT #10	6
	MS15795-807			\				, FLT #8	4
	MS15795-805			\				, FLT #6	4
	MS15795-803			\				, FLT #4	2
	MS35337-83			\				, LOCK 5/16	8
350	MS35337-82			\				WASHER, LOCK 1/4	2

SIZE	CODE IDENT NO	
A	06509	LM 514100
SCALE ——	REV B	SHEET 11

EM FORM 17759C

ITEM	PART NUMBER	ASSY LEVEL 1	2	3	4	5	6	DESCRIPTION, SYM, SPEC, CODE IDENT NO.	QTY REQ
351	MS35337-81			\				WASHER, LOCK #10	6
	14092-6			\				,EPOXY 1/4	2
	14092-7			\				,EPOXY 5/16	8
	14092-5			\				,EPOXY #10	7
355	MW-880-320			\				WASHER, MICA 5/16 DELBERT BLINN	8
	MS35230-68			\				SCREW, P.H. #10-32 X 1 1/4 BRASS	1
	MS51957-52			\				, P. H. #8-32 X 1 3/4	4
	MS51957-36			\				, P. H. #6-32 X 1 1/2	4
	MS51957-22			\				SCREW, P.H. #4-40 X 1 1/4	2
360	115-.196			\				LUG ZIERICK	2
	112-.196			\				LUG ZIERICK	6
	25429-5-7			\				INSERT, INS	2
	25429-6-7			\				INSERT, INS	8
	25429-4-7			\				INSERT, INS	6
365	MS20426AD3			\				RIVET	6
	710438H-1			\				TSTR Q19, 20	2
	214186			\				CHOKE ASSY L11B	1
	214163				\			CUP ASSY	1
	314145				\			CHOKE L11B	1
370	CL-3					\		CORE CARSTEDT	1
	14597-1					\		BOBBIN WESTINGHOUSE	1
	3/16 x 3/16					\		BAND SEAL	1
	3/16 x .006					\		BAND BRONZE	A/R
375	314615			\				CUP ASSY A4	1
	314176				\			CUP	1
	5026-B					\		TERMINAL LERCO	7
	314134				\			TRANSFORMER T9	1
	A22A1					\		CORE EM75574	1
380	#2538					\		TAPE 3M	A/R
	314143				\			CHOKE L9, L10	2
	55046-A2					\		CORE MAG INC.	2
	AFIN645				\			DIODE CR24,25 MIL-E-1/1143	2
	AN961-10			\				WASHER, FLT #10 BRASS	3
385	AN935B10			\				WASHER, LOCK #10 BRONZE	1

SIZE	CODE IDENT NO	
A	06509	LM 514100
SCALE —	REV B	SHEET 12

EM FORM 17759C

ITEM	PART NUMBER	ASSY LEVEL 1 2 3 4 5 6	DESCRIPTION, SYM, SPEC, CODE IDENT NO.	QTY REQ
386	414118	2	PHASE C ASSY	1
	414104	3	HEAT SINK TSTR MT.	1
	10140-2402	4	H-BEAM TIERNEY METALS	1
	MF1001-3	4	NUT PLATE #10-32 KAYNAR	10
390	MF1001-06	4	NUT PLATE #6-32 KAYNAR	2
	MS20426AD3	4	RIVET	36
	NCN-4-6-2	4	CAPTIVE NUT #4-40 NATIONAL RADIO CO	2
	MF1001-08	4	NUT PLATE #8-32 KAYNAR	2
	MK2001-06	4	NUT, ANCHOR #6-32 KAYNAR	2
395	MK2001-08	4	NUT, ANCHOR #8-32 KAYNAR	2
	314174	3	COMP BD ASSY TB3	1
	314173	4	TERM BD ASSY TB3	1
	3025A	5	TERMINAL LERCO	17
	RW-79U34R8F	5	RES R48,49 34.8Ω MIL-R-26	2
400	RW-79U20R0F	5	R51, 52 20Ω	2
	RW-79U1501F	5	R86 1500Ω	1
	RW-79U____F*	5	RES R87 * S.I.T. MIL-R-26	1
	M39003/01-2023	5	CAP C22 120 µF @ 10VDC MIL-C-39003	1
	73531H-120	5	TSTR Q21,22	2
405	10038	5	TRANSIPAD MILTON ROSS	2
	RN55C5112F	5	RES R50 51.1KΩ 710465	1
	314117	3	CUP ASSY A3	1
	314172	4	CUP	1
	3520-B	5	TERMINAL LERCO	2
410	5026-B	5	TERMINAL LERCO	26
	314129	4	TRANSFORMER T8	1
	52038-2A	5	CORE MAG INC	1
	3009-A	5	TERMINAL LERCO	1
415	314127	4	TRANSFORMER T5	1
	A20A1	5	CORE EM75574	1
	314140	4	SATURABLE REACTOR L7	1
	A13A1	5	CORE EM75574	1
420				

SIZE	CODE IDENT NO	
A	06509	LM 514100
SCALE —	REV B	SHEET 13

EM FORM 17759C

ITEM	PART NUMBER	ASSY LEVEL 1 2 3 4 5 6	DESCRIPTION, SYM, SPEC, CODE IDENT NO.	QTY REQ
421				
	214149	\	TERM BD TB6A, B	2
425	3010A	\	TERMINAL LERCO	8
	RW74UR750F	\	RES R68-75 0.75Ω MIL-R-26	8
	JANIN1202	\	DIODE CR20-23, 40, 41 MIL-S-19500/260	6
	79807H	\	TSTR Q41, 48	8
	MS35691-530	\	NUT, HEX 5/16-24	8
430	MS35691-430	\	NUT, HEX 1/4-28	2
	NAS671-C10	\	NUT, HEX #10-32	6
	1747-2	\	WASHER, MICA #10	6
	MW-880-320	\	, MICA 5/16 DELBERT BLINN	8
	MS15795-812	\	, FLT 5/16	8
435	-810	\	, FLT 1/4	2
	-808	\	, FLT #10	6
	-807	\	, FLT #8	4
	-805	\	, FLT #6	4
	MS15795-803	\	, FLT #4	2
440	MS35337-83	\	, LOCK 5/16	8
	MS35337-82	\	, LOCK 1/4	2
	MS35337-81	\	, LOCK #10	6
	14092-6	\	, EPOXY 1/4	2
	14092-7	\	, EPOXY 5/16	8
445	14092-5	\	WASHER , EPOXY #10	6
	MS51957-52	\	SCREW, PAN HD #8-32X 1 3/4	4
	MS51957-36	\	SCREW, PAN HD #6-32X 1 1/2	4
	MS51957-22	\	SCREW, PAN HD #4-40X 1 1/4	2
	112-196	\	LUG ZIERICK	6
450	25429-5-7	\	INSERT, INS 1/4	2
	25429-6-7	\	INSERT, INS 5/16	8
	25429-4-7	\	INSERT, INS #10	6
	MS20426AD3	\	RIVET	6
	710438H-1	\	TSTR Q23, 24	2
455	1747-1	\	WASHER, MICA	2

SIZE	CODE IDENT NO	
A	06509	LM 514100
SCALE —	REV B	SHEET 14

EM FORM 17759C

ITEM	PART NUMBER	ASSY LEVEL 1 2 3 4 5 6	DESCRIPTION, SYM, SPEC, CODE IDENT NO.	QTY REQ
456				
	3146616		CUP ASSY A5	1
460	314176		POTTING CUP	1
	5026-B		TERMINAL LERCO	7
	314134		TRANSFORMER T11	1
	A22A1		CORE EM75574	1
465	*2538		TAPE 3M	A/R
	AFIN645		DIODE CR29,30 MIL-E-1/1143	2
470				
	214186		CHOKE ASSY L11C	1
	214163		CUP ASSY	1
475	314145		CHOKE L11C	1
	CL-3		CORE CARSTEDT	1
	14597-1		BOBBIN WESTINGHOUSE	1
	3/16 X 3/16		BAND SEAL	1
	3/16 X .006		BAND BRONZE	A/R
480				
485				
490				

SIZE	CODE IDENT NO	
A	06509	LM 514100
SCALE ——	REV B	SHEET 15

ITEM	PART NUMBER	ASSY LEVEL 1 2 3 4 5 6	DESCRIPTION, SYM, SPEC, CODE IDENT NO.	QTY REQ
491				
495				
500	414111	2	PHASE A ASSEMBLY	1
	414105	3	HEAT SINK TSTR MOUNT	1
	10140-2402	4	H-BEAM TIERNEY METALS	1
			6061-T6-511	
	MF1001-3	4	NUT PLATE #10-32 KAYNAR	10
505	NCN-4-6-2	4	CAPTIVE NUT #4-40	2
			NATIONAL RADIO CO	
	MS20426AD3	4	RIVET	32
	MF1001-08	4	NUTPLATE #8-32 KAYNAR	2
	MK2001-06	4	NUT, ANCHOR #6-32 KAYNAR	2
510	MK2001-08	4	NUT, ANCHOR #8-32 KAYNAR	2
	314109	3	COMP BD ASSY TB1	1
	314108	4	TERMINAL BD ASSY	1
	3025A	5	TERMINAL LERCO	24
515	RN55C1272F	4	RES R38 710465 12.7KΩ	1
	3009-A	5	TERMINAL LERCO	3
	RW-79U1001F	4	RES R39 MIL-R-26	1
	RN55C1272F	4	R40 710465 12.7KΩ	1
	RW-79U20R0F	4	RES R41,42 MIL-R-26	2
520	CYK01BV333K	4	CAP C11 PER 711476 0.033µF @	1
			200VDC	
	LP8A1C224K	4	C12,13 DEARBORN	2
			0.022µF @ 200VDC	
	LP8A1C474K	4	CAP C14 0.47µF @ 200VDC	1
525			DEARBORN	

SIZE	CODE IDENT NO	
A	06509	LM 514100
SCALE ———	REV B	SHEET 16

EM FORM 17759C

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ITEM	PART NUMBER	ASSY LEVEL 1 2 3 4 5 6	DESCRIPTION SYM, SPEC, CODE IDENT NO.	QTY REQ
526	M39003/01-2019		CAP C15 MIL-C-39003	1
			39 uf@ 10VDC	
	M39003/01-2066		CAP C16 MIL-C-39003	1
			22 uf@ 35VDC	
530	73531H-120		TSTR Q13,14	2
	RN55C----F*		RES R99* S.I.T. APPROX. 10K 710465	1
	AFIN645		DIODE CR8,9 MIL-E-1/1143	2
	314139		CHOKE L5	1
	33449BF10F02-0		POTTING CUP	1
535	10W5Z		CORE 711488	1
	10038		TRANSIPAD MILTON ROSS	2
540				
	314120		CUP ASSY A1	1
	314119		POTTING CUP	1
	3520-B		TERMINAL LERCO	2
	5026-B		TERMINAL LERCO	36
545				
	314128		TRANSFORMER T6	1
	52038-2A		CORE MAG INC	1
550	314143		TRANSFORMER T3	1
	A20A1		CORE EM75574	1
	314140		SATURABLE REACTOR L6	1
	A13A1		CORE EM75574	1
555				
	314141		CHOKE L8	1
	55310-2A		CORE MAG INC.	1
	AFIN645		DIODE CR10,11 MIL-E-1/1143	2
560	76014H		DIODE CR34,35 GE	2

SIZE	CODE IDENT NO	
A	06509	LM 514100
SCALE ——	REV B	SHEET 17

ITEM	PART NUMBER	ASSY LEVEL 1 2 3 4 5 6	DESCRIPTION, SYM, SPEC, CODE IDENT NO.	QTY REQ
561	313556		TRANSFORMER T10A	1
	AFIN645		DIODE CR27,28	2
	313555-1		POTTING CUP ASSY	1
565	313555-2		CUP	1
	5026-A		TERMINAL LERCO	4
	14101-4A28		TUBE	1
570				
	314133		XMFR T10A	1
	A22A1		CORE EM75574	1
	#2538		TAPE 3M	A/R
575				
580	314189		MODULE ASSY A9	1
	314185		POTTING CUP	1
	3025-A		TERMINAL LERCO	10
	314187		WELDED MODULE ASSY	1
	A314187-2		POSITIONER (ARTWORK)	1
585	A314187-3		POSITIONER (ARTWORK)	1
	RN60C1403F		RES R81 140KΩ 75908	1
	RN55C3012F		R82 30.1KΩ 710465	1
	C3831F		R83 3.83KΩ 710465	1
	RN55C5361F		R78 5.36K 710465	1
590	RN55C----*F		R84A* S.I.T ≈ 200KΩ 710465	1
	RN55C----*F		R84B* S.I.T. ≈ 800KΩ 710465	1
	RN55C1001F		RES R85A R85B 710465	2
			1.0KΩ	
	M39003/01-2066		CAP C20 MIL-C-39003	1
595			22µf @ 35VDC	

SIZE	CODE IDENT NO	
A	06509	LM 514100
SCALE ——	REV B	SHEET 18

EM FORM 17759C

ITEM	PART NUMBER	ASSY LEVEL 1 2 3 4 5 6	DESCRIPTION, SYM, SPEC, CODE IDENT NO.	QTY REQ
596	M39003/01-2055		CAP C21B MIL-C-39003	1
			47µF @ 20VDC	
	79430H		DIODE CR26A, CR26B	2
			PS12034A/B	
600	74762H		TSTR Q49	1
	74706H		TSTR Q50	1
	M39003/01-2055		CAP C21A 47µF@20VDC MIL-C-39003	1
	RN55C___F*		RES R80 S.I.T. = 100KΩ 710465	1
	RN55C____F*		RES R84 S.I.T. = 200KΩ 710465	1
605	214149		TERM BD TB4A & TB4B	2
	3010A		TERMINAL LERCO	8
	AN961-10		WASHER, FLT #10 BRASS	3
610	AN935B10		WASHER, LOCK #10 BRONZE	1
	RW74UR750F		RES R53-R59, R99 MIL-R-26	8
	JANIN1202		DIODE CR12-15,36,37 MIL-S-19500/260	6
	79807H		TSTR Q25-32	8
	MS35691-530		NUT, HEX 5/16-24	8
615	MS35691-430		NUT, HEX 1/4-28	2
	AN345B10		NUT, HEX #10-32 BRASS	1
	1747-2		WASHER, MICA #10	6
	MS15795-812		WASHER, FLT 5/16	8
620	-810		, FLT 1/4	2
	-808		, FLT #10	6
	-807		, FLT #8	4
	-805		, FLT #6	2
	MS15795-803		, FLT #4	2
625	MS35337-83		, LOCK 5/16	8
	MS35337-82		, LOCK 1/4	2
	MS35337-81		, LOCK #10	6
	14092-6		, EPOXY 1/4	2
	14092-7		, EPOXY 5/16	8
630	14092-5		WASHER, EPOXY #10	7

SIZE	CODE IDENT NO	
A	06509	LM 514100
SCALE ——	REV B	SHEET 19

ITEM	PART NUMBER	ASSY LEVEL 1	2	3	4	5	6	DESCRIPTION, SYM, SPEC, CODE IDENT NO.	QTY REQ
631	MW-880-320			\				WASHER, MICA 5/16 DELBERT BLINN	8
	MS35230-68			\				SCREW, PAN HD. #10-32 X 1 1/4 BRASS	1
	MS51957-52			\				, PAN HD #8-32 X 1 3/4	4
	MS51957-37			\				, PAN HD #6-32 X 1 3/4	2
635	MS51957-22			\				SCREW PAN HD #4-40 X 1 1/4	2
	115-196			\				LUG ZIERICK	2
	112-196			\				LUG ZIERICK	6
	25429-5-7			\				INSERT, INSULATOR	2
	25429-6-7			\				INSERT, INSULATOR	8
640	25429-4-7			\				INSERT, INSULATOR	6
	MS20426AD3			\				RIVET	6
	710438H-1			\				TSTR Q15, 16	2
	214186			\				CHOKE ASSY L11A	1
	214163				\			CUP ASSY	1
645	314145				\			CHOKE L11A	1
	CL-3					\		CORE CARSTEDT	1
	14597-1					\		BOBBIN WESTINGHOUSE	1
	3/16 X 3/16					\		BAND SEAL	1
	3/16 X .006					\		BAND, BRONZE	A/R
650									
	1747-1			\				WASHER, MICA	2
	25429-4-3			\				INSERT, INSULATOR	1
	NAS671-C10			\				NUT	6
	314148		\					RFI ASSEMBLY	1
655	314181			\				RFI SHIELD	1
	LHA27M2860-62				\			NUTPLATE ESNA	4
	MS20426AD2				\			RIVET	8
	314167			\				COMP BD ASSY	1
	314166				\			TERM BD ASSY	1
660	3010-A					\		TERMINAL LERCO	9
	4030-B					\		TERMINAL LERCO	1
	314135				\			CHOKE L1, L3	2
	33449AG9F02-0					\		POTTING CUP	1
						\		CORE MAG INC	1
665	77308-4				\			CAP C26, 27	2

SIZE	CODE IDENT NO	
A	06509	LM 514100
SCALE —	REV B	SHEET 20

ITEM	PART NUMBER	ASSY LEVEL 1 2 3 4 5 6	DESCRIPTION SYM, SPEC, CODE IDENT NO.	QTY REQ
666	LP8A1C334K	4	CAP C17, 19, 23 0.33 uf @ 200VDC DEARBORN	3
	214178	3	IDENT PLATE	1
	MS35649-64	3	NUT, HEX #6-32	4
	AN345B416	3	NUT, HEX 1/4-28 BRASS	18
670	MS15795-805	3	WASHER, FLT #6	8
	AN961-416	3	, FLT 1/4 BRASS	19
	MS35337-79	3	, LOCK #6	4
	AN935B416	3	WASHER, LOCK 1/4 BRONZE	14
	MS 51957-30	3	SCREW, PAN HD #6-32 X 1/2	2
675		3		
	10800PB428-44	3	STUD 1/4-28 X 2 3/4	4
	127-281	3	LUG ZIERICK	10
	MS35230-83	3	SCREW, PAN HD. 1/4-28 X 1" BRASS	1
	MS35489-4	3	GROMMET	1
680	MS24693-C32	3	SCREW, PAN HD #6-32 X 1	2
685				
690				
	313496	2	FILTER ASSY FL1	1
695	313496-2	3	CHOKE L2A, L2B	2
	14597-17	3	COIL FORM	4
	CH-7	3	CORE CARSTEDT	2
	32996	3	LUG AMP	4
	1294-363	3	BAND, SEAL WEST	2
700	3/8 X .012	3	BAND, STL WEST	A/R

SIZE	CODE IDENT NO	
A	06509	LM 514100
SCALE —	REV B	SHEET 21

EM FORM 17759C

ITEM	PART NUMBER	ASSY LEVEL 1 2 3 4 5 6	DESCRIPTION SYM, SPEC, CODE IDENT NO.	QTY REQ
701	413510-1		BRACKET	1
	413510-2		BRACKET	1
	MF1301-06		NUT-ANCHOR KAYNAR	6
	K7001-06-6		CLINCH NUT KAYNAR	6
705	MS20426-AD2		RIVET	12
	314122		TERM BD TB11	1
	MS35233-28		SCREW	2
	NAS620A6L		WASHER, FLAT	2
	75576-34		CAP C10A, C10B 660 ufd	2
710			@ 75VDC GE 29F SERIES	
	SST-2B		CABLE-TIE MS17821-1-9	4
			PANDUIT	
715				
	627 X .169		LUG ZIERICK	9
	MS24693-C26		SCREW	4
	MS35230-45		SCREW	4
720	AN935B8		WASHER, LOCK	4
	AN961-8		WASHER, FLAT	8
	MS35650-85		NUT	4
	267566-32X16		INSUL BD	4
725				
	313497		COMP BD ASSY TB10	1
	213558		RES R7	1
	MS24693-C26		SCREW	2
730	573-.156		LUG ZIERICK	3
	MS15795-805		WASHER, FLAT	2
	MS35337-79		WASHER, LOCK	2
	MS35649-64		NUT, HEX	2
735				

SIZE	CODE IDENT NO	
A	06509	LM 514100
SCALE ——	REV B	SHEET 22

EM FORM 17759C

APPENDIX II

WAVEFORM PHOTOGRAPHS (BREADBOARD)

AND

ACCEPTANCE TEST RECORD FORMS

(UNIT SERIAL NUMBER 25506)

WAVEFORM PHOTOGRAPHS

1. Figures 1 and 2 show initial inrush current when the inverter is not operating. This current is charging the audio filter capacitors. The peak current is approximately 260 amperes.

2. Figures 3 through 6 show inrush currents on both running and starting loads at 50 and 60 volts DC input.

3. Figures 7 through 10 cover the induced ripple kicked back into the DC power source during running and starting loads at both 50 and 60 volts DC. The maximum inverter ripple is 2.8 amperes peak-to-peak at 2400 Hz. The 3.3 amps peak-to-peak is a result of modulation or ripple from the DC power source. This ripple has a 320 Hz rep rate.

4. Figure 11 shows the AC Instrumentation output. This signal does not meet the specification requirements as far as peak-to-peak amplitude. This will be corrected on the production units by changing the transformer turns ratio.

5. Figures 12 and 13 show Q11, V_{CE} Vs. I_C, at running load and 50 to 60 volts DC input. Q1 is the pass or control element in the pulse width regulator that supplies regulated DC power to the driver stages.

6. Figures 14 and 15 show Q1, V_{CE} Vs. I_C, at starting load under both 50 and 60 volts DC input. There is a low frequency modulation appearing on both the V_{CE} and I_C waveforms. This is a result of the induced ripple

from the inverter passing load current through the sense resistor, R7. There is a difference of approximately one ampere peak between Figures 13 and 15. This is a result of the increased drive power supplied during starting load.

7. Figures 16 and 17 show V_{CE} Vs. I_C for Q11. Q11 is the series control element in the low level series regulator that supplies power to the oscillator stages.

8. Figures 18 through 21 show V_{CE} and I_C waveforms for Q13, an AØ oscillator transistor, at both loads and 60 volts DC input. Figures 26 through 29 cover the same points for Q17, a BØ oscillator transistor, for comparison with Q13

9. Figures 22 through 25 show V_{CE} and I_C waveforms for Q15, an AØ driver transistor, at both loads and 60 volts DC input. Figures 30 through 33 cover the same points for Q19, a BØ oscillator transistor, for comparison with Q15. The difference between the current waveforms, figures 23 and 25, is a result of the reactive energy difference between running and starting loads. There is more energy kicked back into the inverter output stage. This current passes through the output transistor emitter-base diode placing an additional load on the driver stage.

10. Figures 34 and 35 show the V_{CE} waveform of Q25, an output transistor during running load at 50 and 60 volts DC. Figures 38 and 39 cover the same points but at starting load.

11. Figures 36 and 37 show the I_C waveform for Q25. During running load and input voltages of 50 and 60 volts DC. the negative current is a result of reactive loading. Figures 40 and 41 show the same conditions but at starting load.

12. Figures 42 and 43 show the forward current that passes through CR12 and CR14 during running load and at 50 and 60 volts DC input. As the load P.F. is approximately 0.8 lagging at these conditions, there is very little reactive current.

13. Figures 44 and 45 show the forward current that passes through CR12 and CR14 during starting load and at 50 and 60 volts DC input. The load P.F. is approximately 0.3 lagging at this condition. The peak forward current is 50 amperes for less than 1/6 of a cycle.

14. Figures 46 through 49 show V_{CE} Vs. I_{line} for running and starting loads at 50 and 60 volts DC input.

15. Figures 50 through 53 show V_{A-B} Vs. I_{line} for running and starting loads at 50 and 60 volts DC.

INRUSH CURRENT

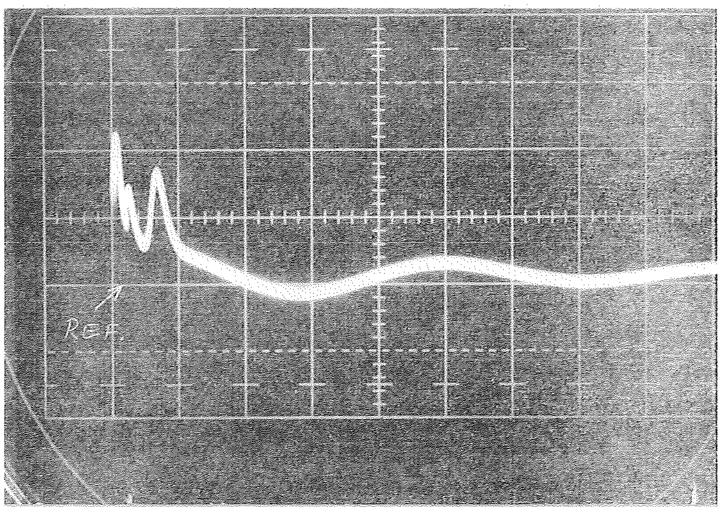


FIGURE 1
Vert. = 100 Amp/Cm
Horiz. = 1 MS/Cm
Input = 50 Volts DC
Load = No Load

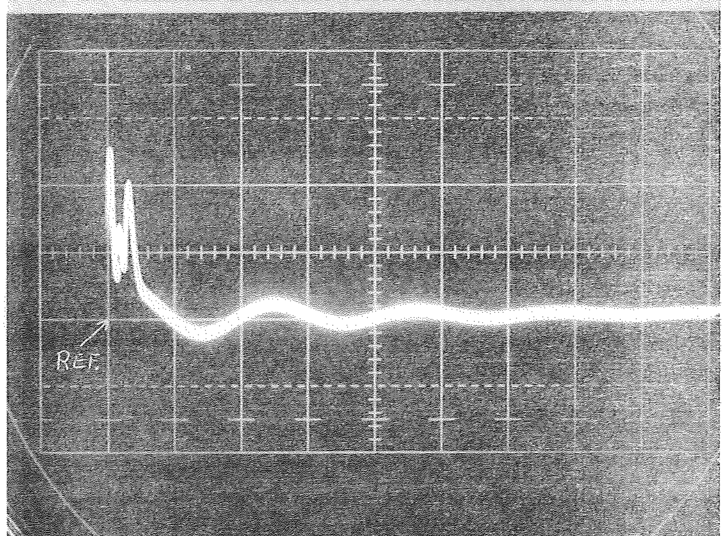


FIGURE 2
Vert. = 100 Amp/Cm
Horiz. = 2 MS/Cm
Input = 60 Volts DC
Load = No Load

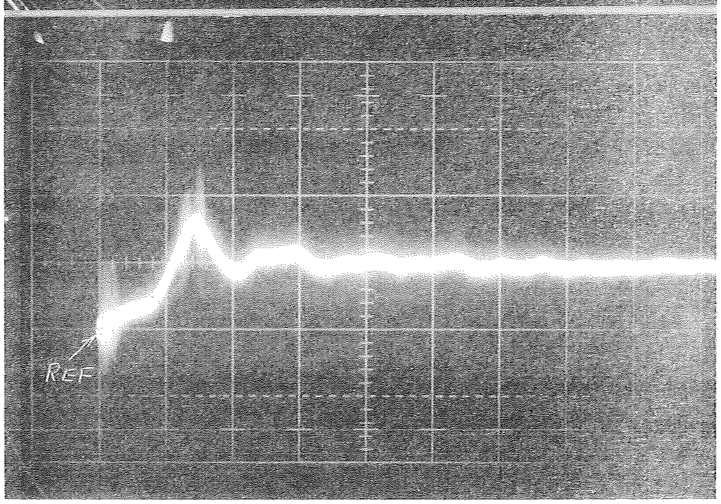


FIGURE 3
Vert. = 20 Amp/Cm
Horiz. = 2 MS/Cm
Input = 50 Volts DC
Load = Running

CODE IDENT NO.	SIZE	
06509	A	
SCALE		SHEET

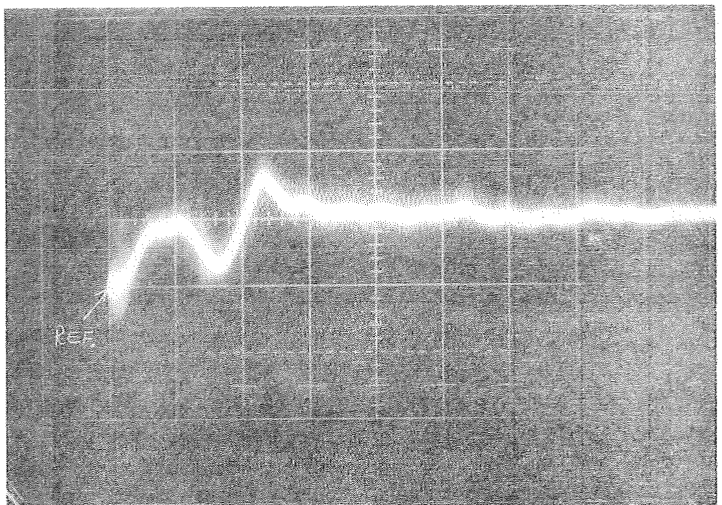


FIGURE 4
Vert. = 20 Amp/Cm
Horiz. = 2 MS/Cm
Input = 60 Volts DC
Load = Running

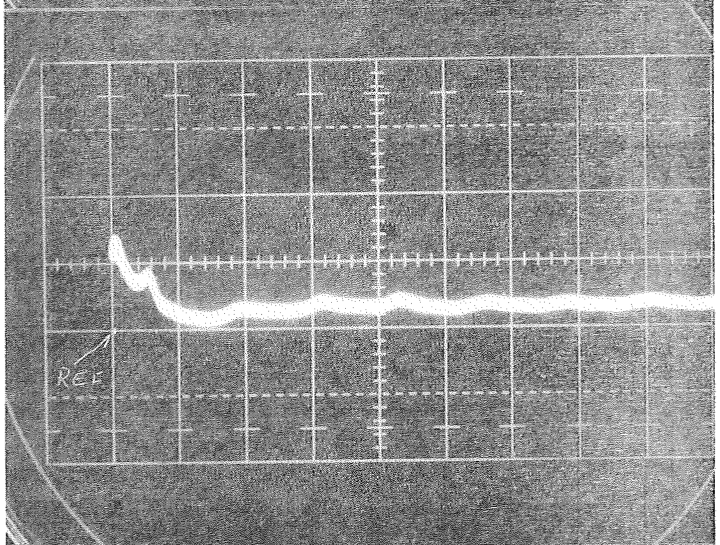


FIGURE 5
Vert. = 100 Amp/Cm
Horiz = 1 MS/Cm
Input = 50 Volts DC
Load = Starting

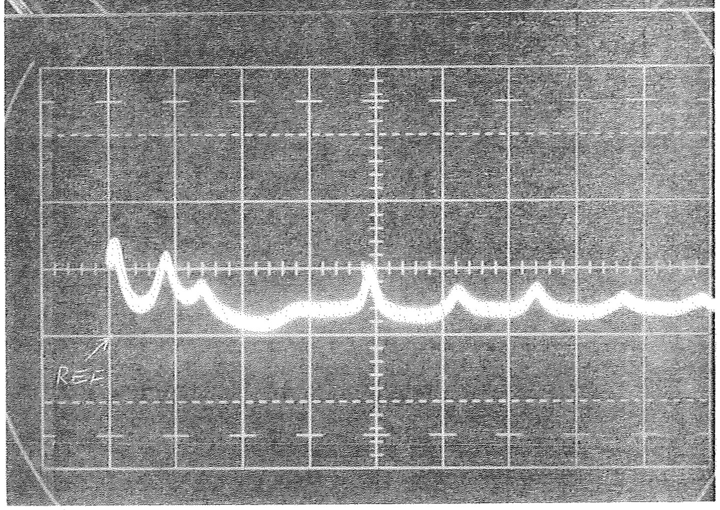


FIGURE 6
Vert. = 100 Amp/Cm
Horiz = 1 MS/Cm
Input = 60 Volts DC
Load = Starting

CODE IDENT NO.	SIZE	
06509	A	
SCALE		SHEET

INDUCED RIPPLE

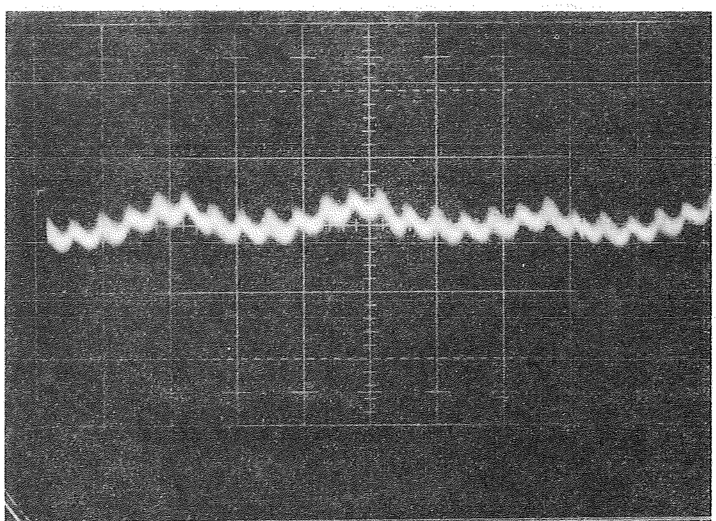


FIGURE 7
Vert. = 1 Amp/Cm
Horiz. = 1 MS/Cm
Input = 50 Volts DC
Load = Running

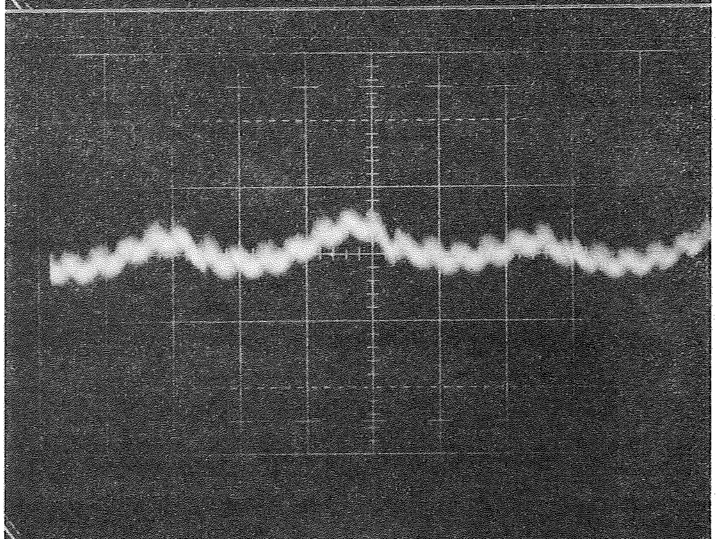


FIGURE 8
Vert. = 1 Amp/Cm
Horiz. = 1 MS/Cm
Input = 60 Volts DC
Load = Running

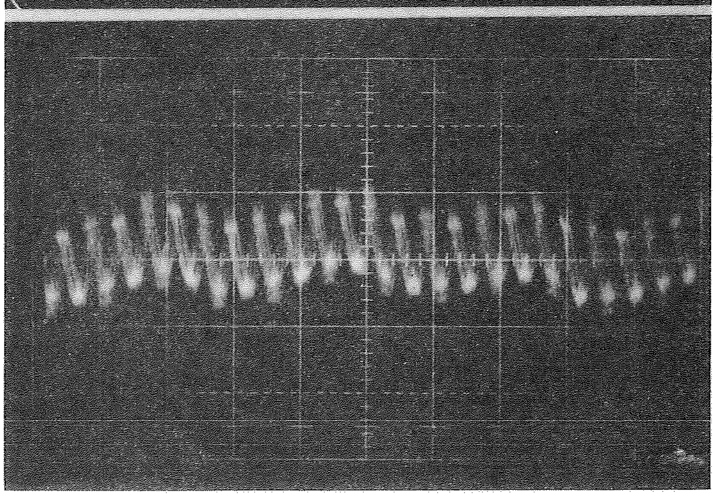


FIGURE 9
Vert. = 1 Amp/Cm
Horiz. = 1 MS/Cm
Input = 50 Volts DC
Load = Starting

CODE IDENT NO.	SIZE	
06509	A	
SCALE		SHEET

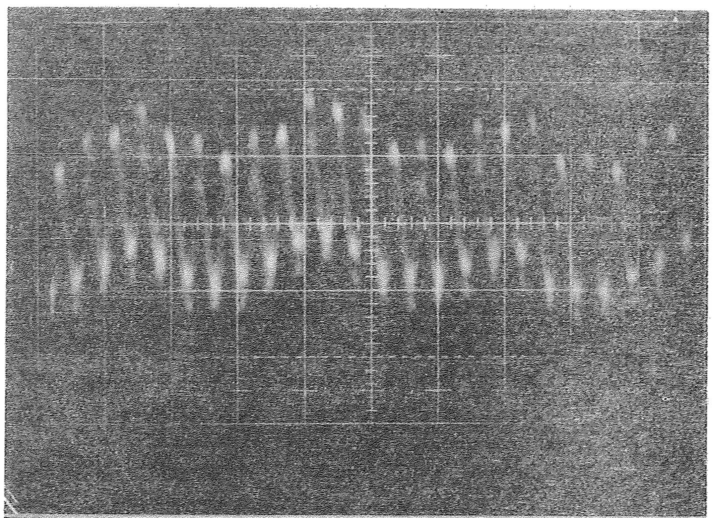


FIGURE 10
Vert. = 1 Amp/Cm
Horiz. = 1 MS/Cm
Input = 60 Volts DC
Load = Starting

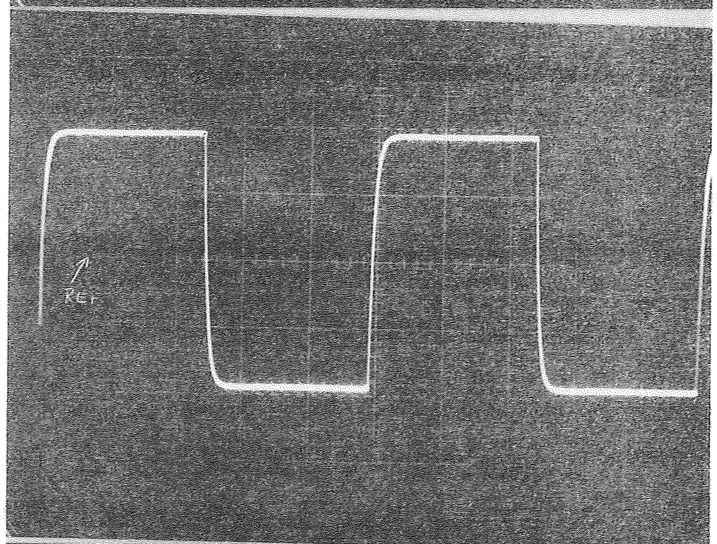
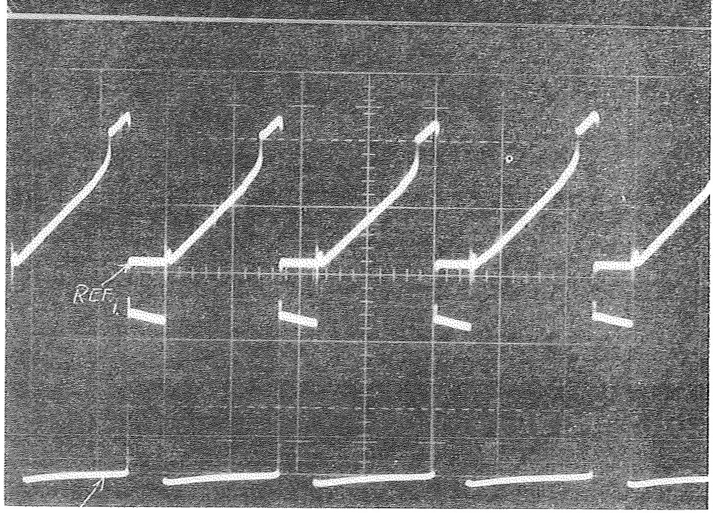


FIGURE 11
Vert. = 2 Volts/Cm
Horiz. = 500 μs/Cm
Input = 60 Volts DC



Q1 V_{CE} Vs. I_C

FIGURE 12
Vert. 1 = 1 Amp/Cm
Vert. 2 = 20 Volts/Cm
Horiz. = 50 μs/Cm
Input = 50 Volts DC
Load = Running

CODE IDENT NO.	SIZE	
06509	A	
SCALE		SHEET

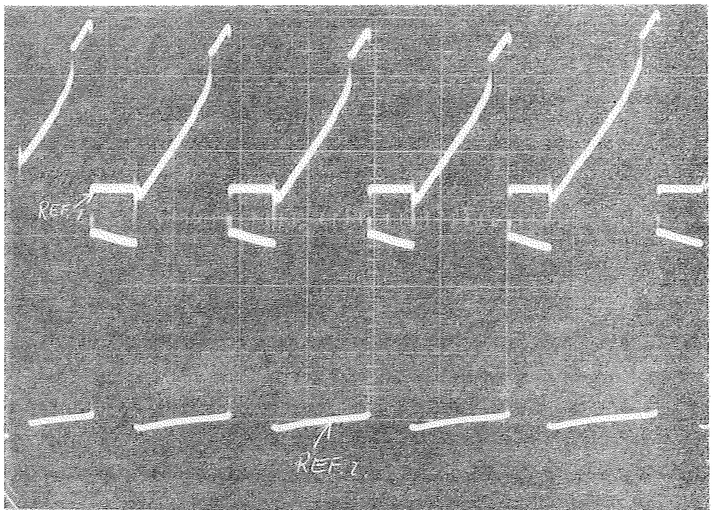


FIGURE 13
Vert. 1 = 1 Amp/Cm
Vert. 2 = 20 Volts/Cm
Horiz. = 50 μs/Cm
Input = 60 Volts DC
Load = Running

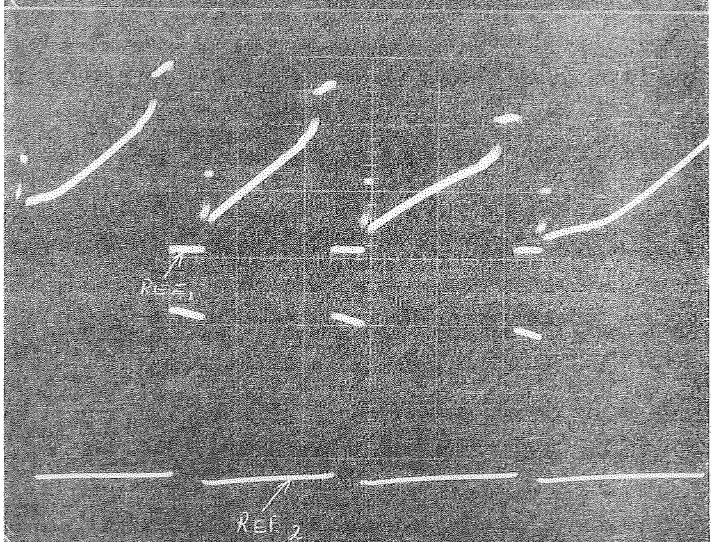


FIGURE 14
Vert. 1 = 1 Amp/Cm
Vert. 2 = 20 Volts/Cm
Horiz. = 50 μs/Cm
Input = 50 Volts DC
Load = Starting

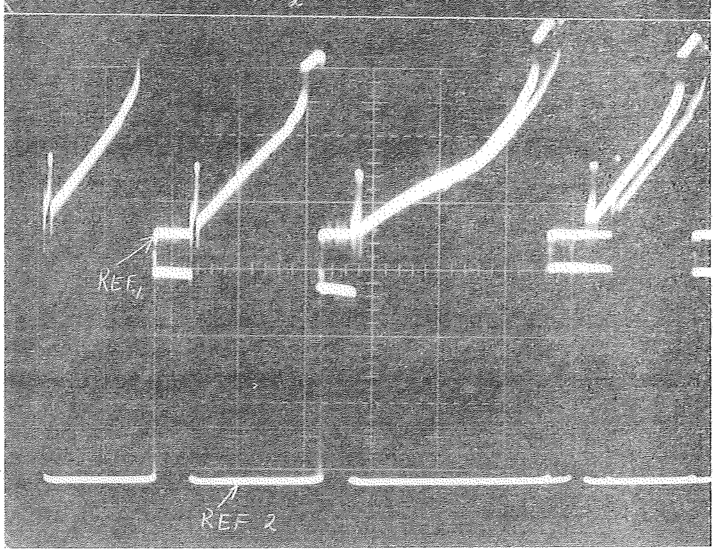


FIGURE 15
Vert. 1 = 1 Amp/Cm
Vert. 2 = 20 Volts/Cm
Horiz. = 50 μs/Cm
Input = 60 Volts DC
Load = Starting

CODE IDENT NO.	SIZE	
06509	A	
SCALE		SHEET

Q11 V_{CE} Vs. I_C

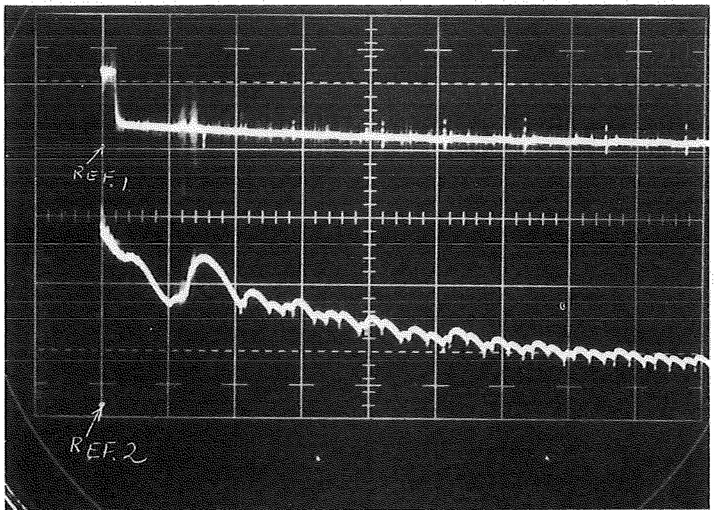


FIGURE 16
Vert. 1 = 0.5 Amp/Cm
Vert. 2 = 20 Volts/Cm
Horiz. = 2 MS/Cm
Input = 50 Volts DC
Load = Starting

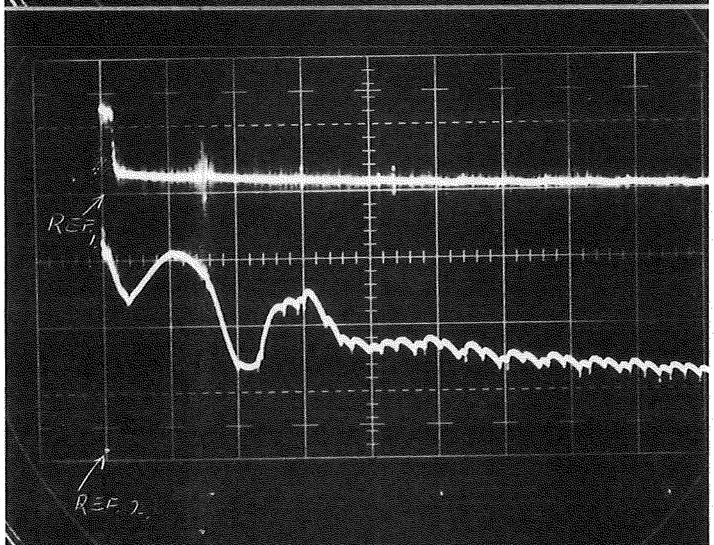


FIGURE 17
Vert. 1 = 0.5 Amp/Cm
Vert. 2 = 20 Volts/Cm
Horiz. = 2 MS/Cm
Input = 60 Volts DC
Load = Starting

Q13 V_{CE}

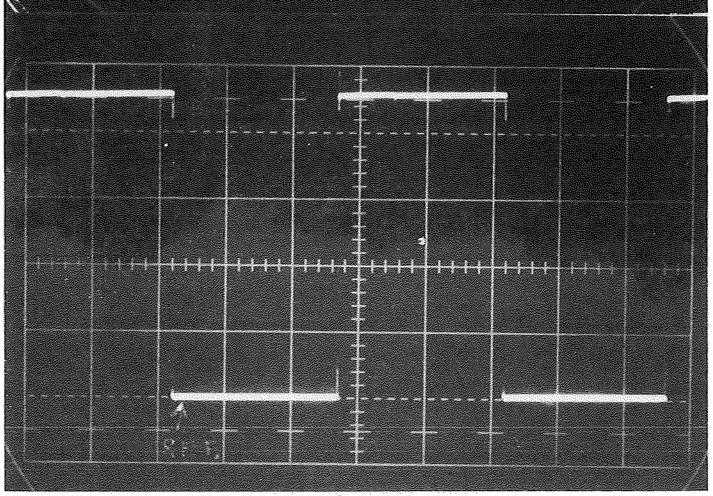
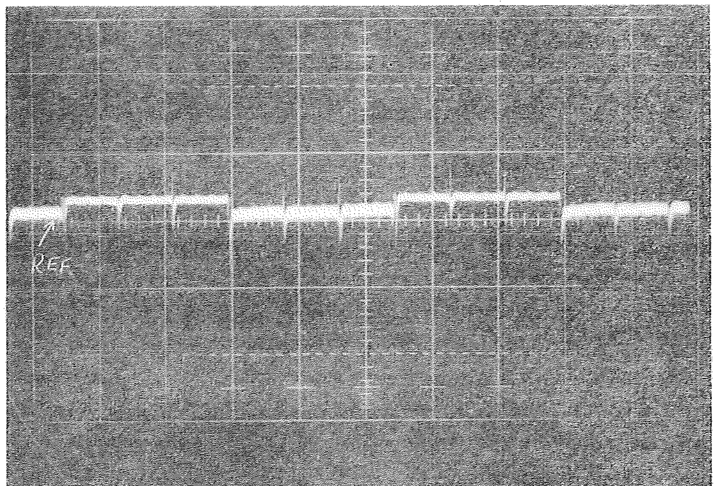


FIGURE 18
Vert. = 20 Volt/Cm
Horiz. = 500 μs/Cm
Input = 60 Volts DC
Load = Running

CODE IDENT NO.	SIZE	
06509	A	
SCALE		SHEET



Q13 I_C

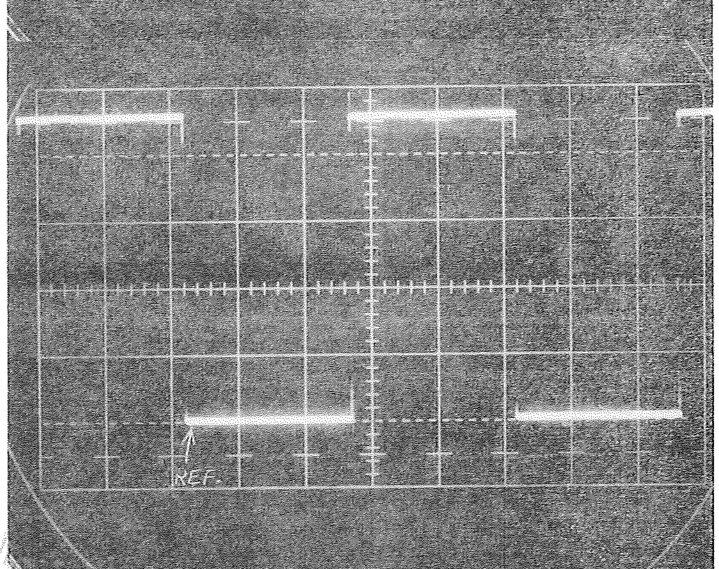
FIGURE 19

Vert. = 0.1 Amp/Cm

Horiz. = 500 µs/Cm

Input = 60 Volts DC

Load = Running



Q13 V_{CE}

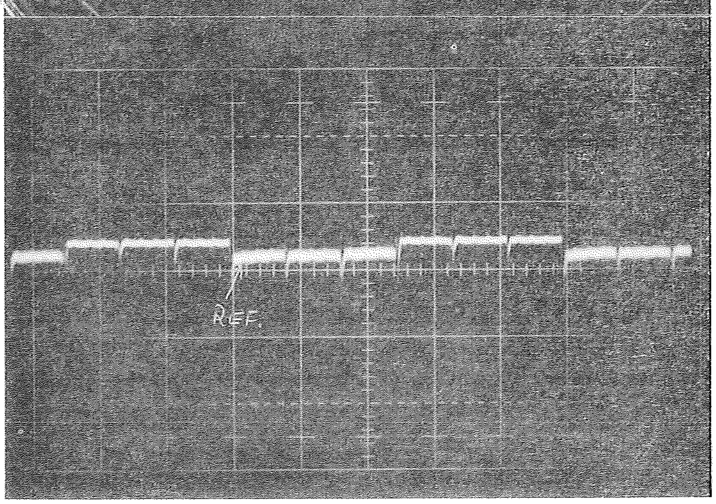
FIGURE 20

Vert. = 20 Volt/Cm

Horiz. = 500 µs/Cm

Input = 60 Volts DC

Load = Starting



Q13 I_C

FIGURE 21

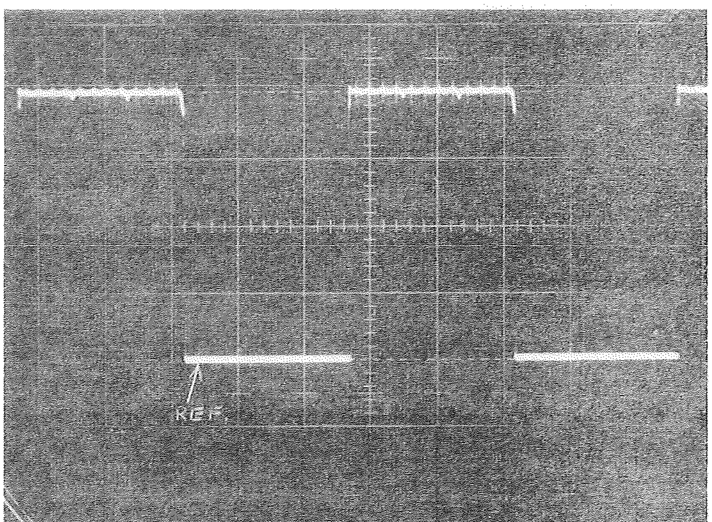
Vert. = 0.1 Amp/Cm

Horiz. = 500 µs/Cm

Input = 60 Volts DC

Load = Starting

CODE IDENT NO.	SIZE	
06509	A	
SCALE		SHEET



Q15 V_{CE}

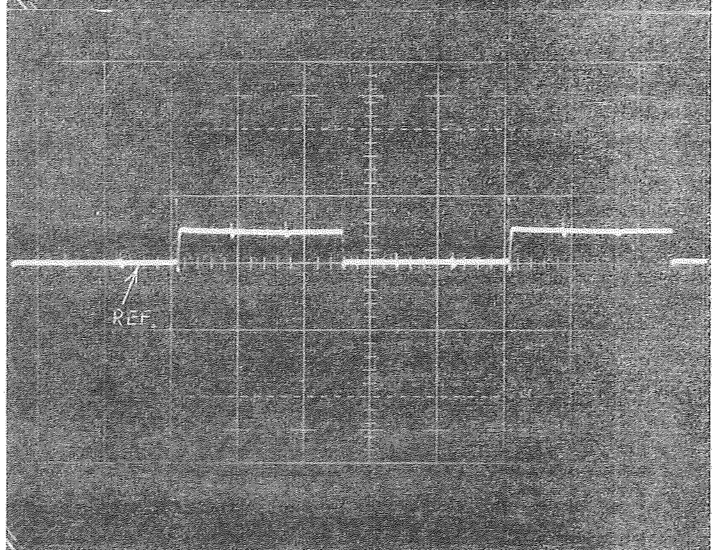
FIGURE 22

Vert. = 20 Volts/Cm

Horiz. = 500 μs/Cm

Input = 60 Volts DC

Load = Running



Q15 I_C

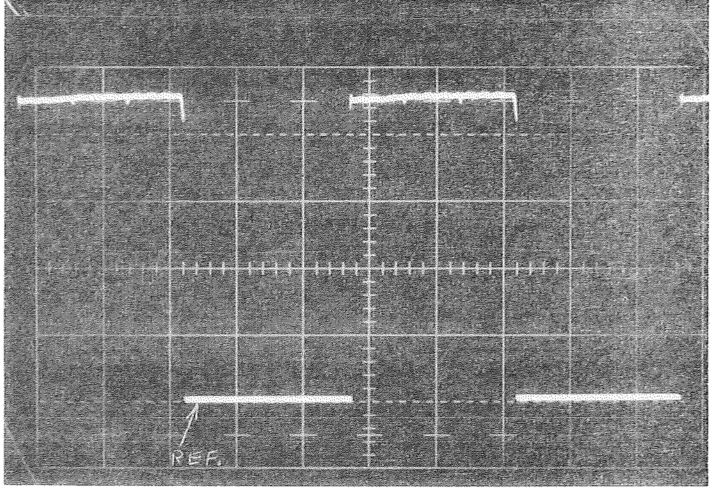
FIGURE 23

Vert. = 1 Amp/Cm

Horiz. = 500 μs/Cm

Input = 60 Volts DC

Load = Running



Q15 V_{CE}

FIGURE 24

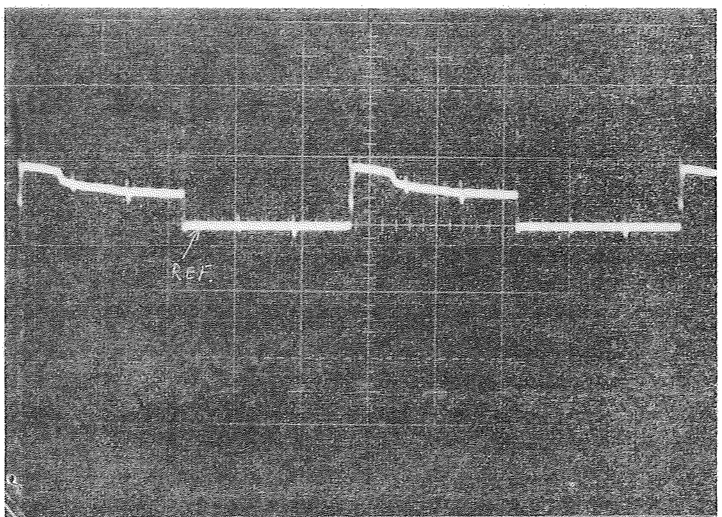
Vert. = 20 Volts/Cm

Horiz. = 500 μs/Cm

Input = 60 Volts DC

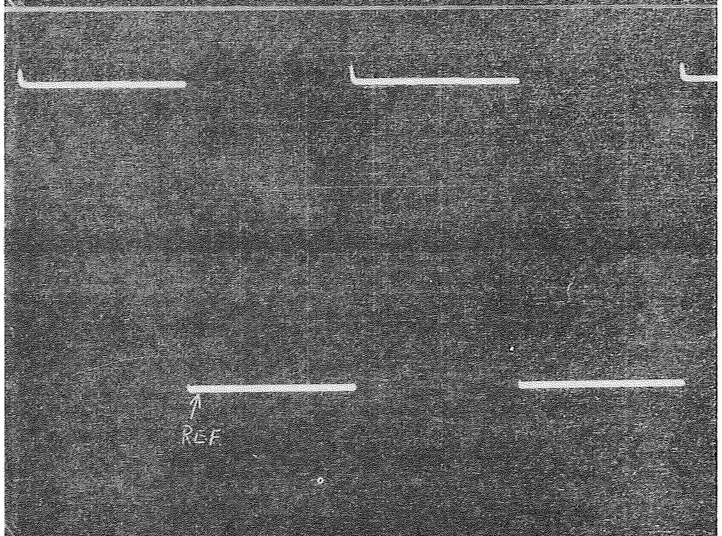
Load = Starting

CODE IDENT NO.	SIZE	
06509	A	
SCALE		SHEET



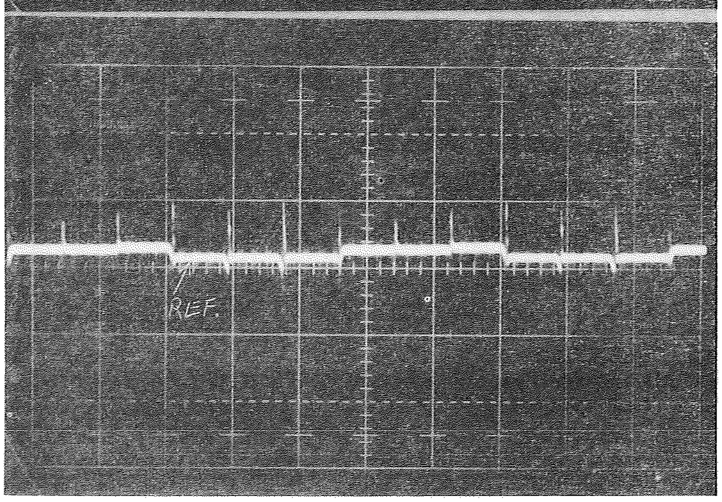
Q15 I_C

FIGURE 25
Vert. = 1 Amp/Cm
Horiz. = 500 μs/Cm
Input = 60 Volts DC
Load = Starting



Q17 V_{CE}

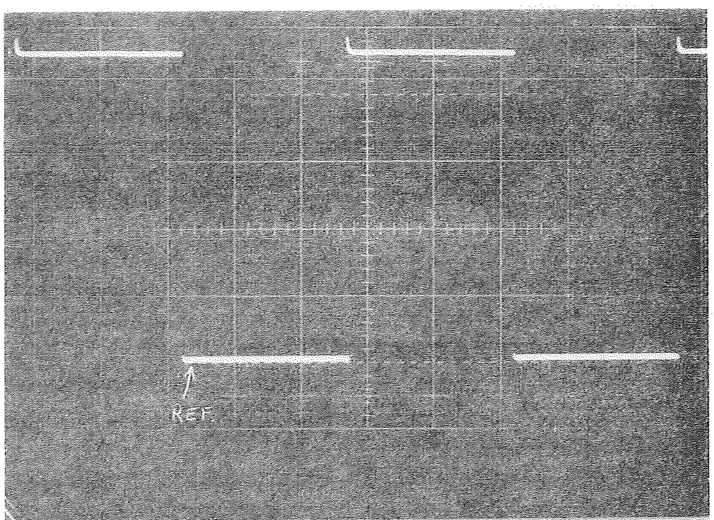
FIGURE 26
Vert. = 20 Volt/Cm
Horiz. = 500 μs/Cm
Input = 60 Volts DC
Load = Running



Q17 I_C

FIGURE 27
Vert. = 0.1 Amp/Cm
Horiz. = 500 μs/Cm
Input = 60 Volts DC
Load = Running

CODE IDENT NO.	SIZE	
06509	A	
SCALE		SHEET



Q17 V_{CE}

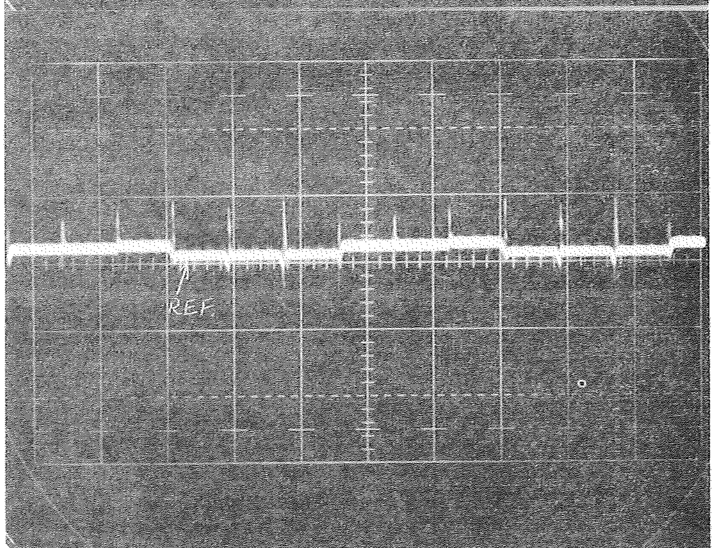
FIGURE 28

Vert. = 20 Volt/Cm

Horiz. = 500 μs/Cm

Input = 60 Volts DC

Load = Starting



Q17 I_C

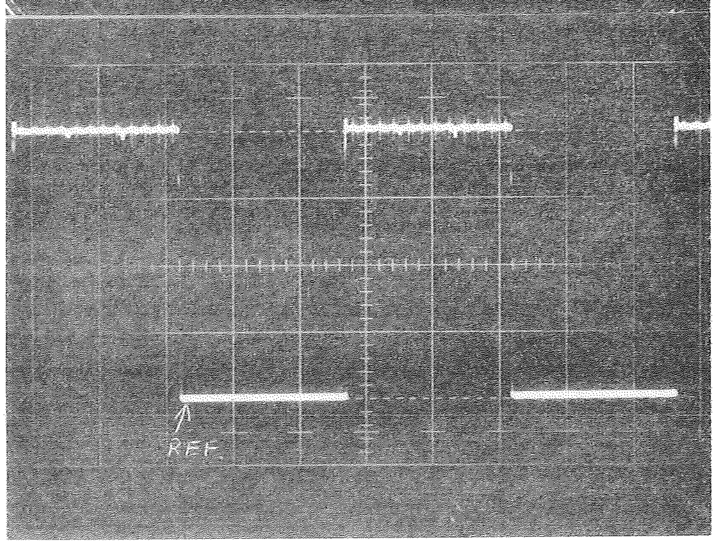
FIGURE 29

Vert. = 0.1 Amp/Cm

Horiz. = 500 μs/Cm

Input = 60 Volts DC

Load = Starting



Q19 V_{CE}

FIGURE 30

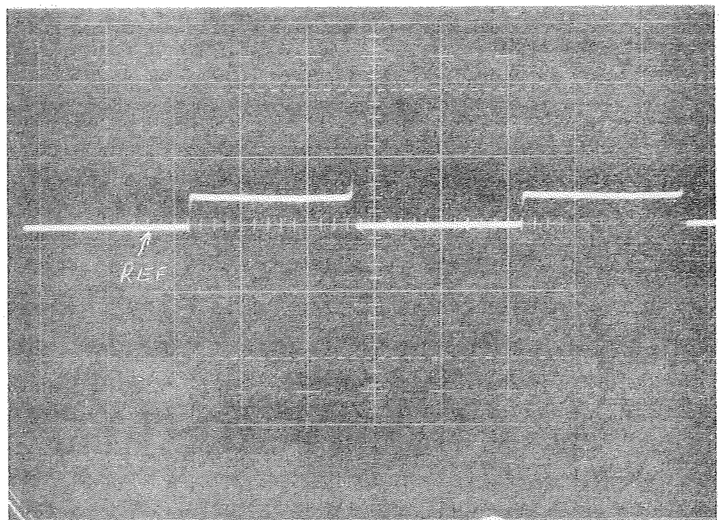
Vert. = 20 Volt/Cm

Horiz. = 500 μs/Cm

Input = 60 Volts DC

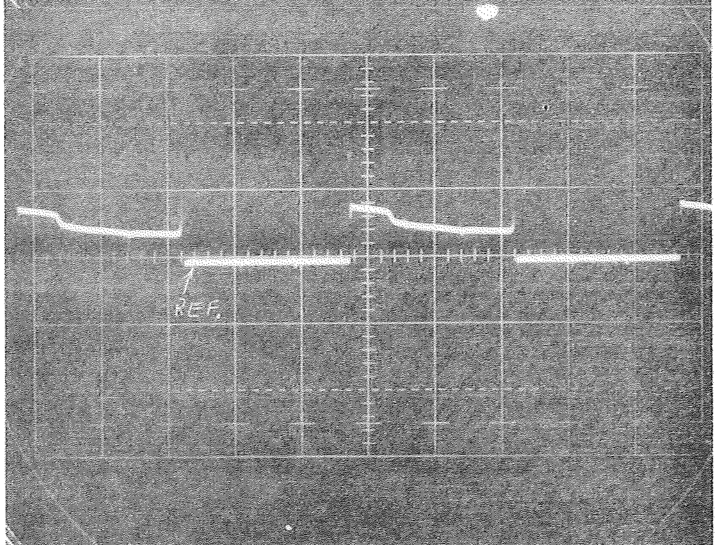
Load = Running

CODE IDENT NO.	SIZE	
06509	A	
SCALE		SHEET



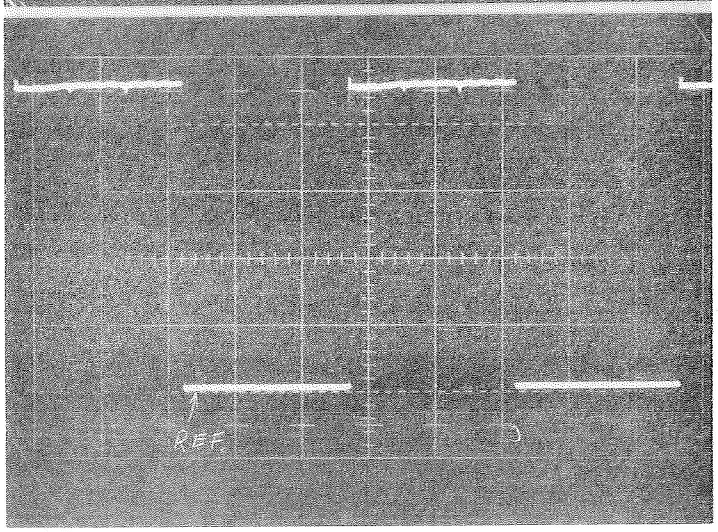
Q19 I_C

FIGURE 31
Vert. = 1 Amp/Cm
Horiz. = 500 μs/Cm
Input = 60 Volts DC
Load = Running



Q19 I_C

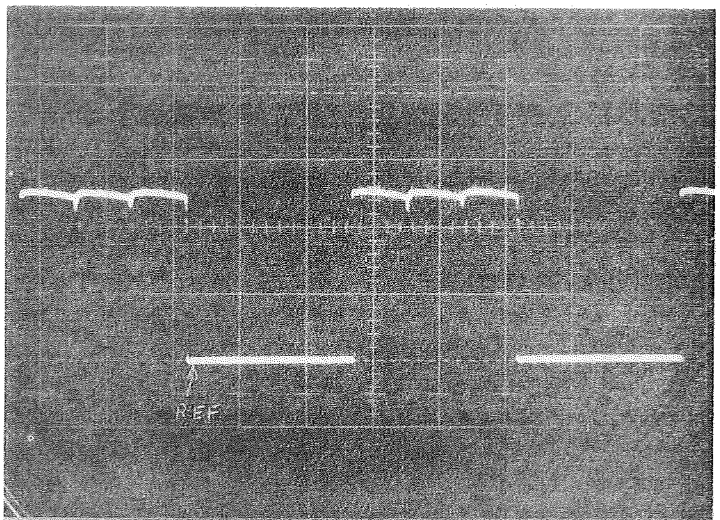
FIGURE 32
Vert. = 1 Amp/Cm
Horiz. = 500 μs/Cm
Input = 60 Volts DC
Load = Starting



Q19 V_{CE}

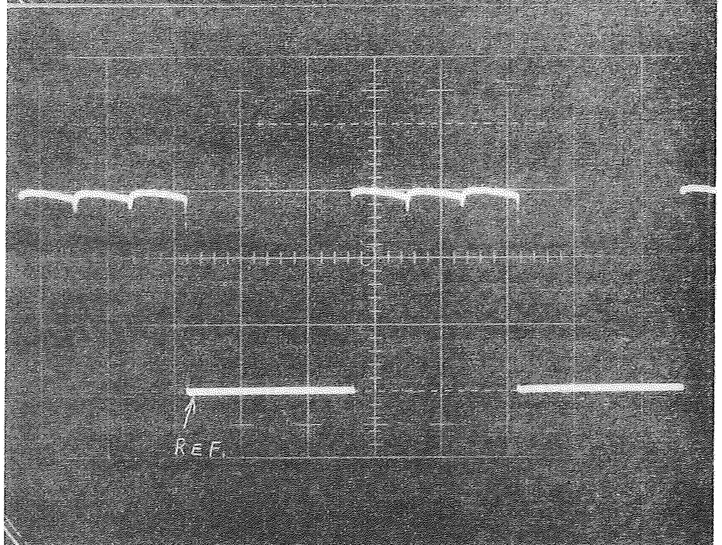
FIGURE 33
Vert. = 20 Volts/Cm
Horiz. = 500 μs/Cm
Input = 60 Volts DC
Load = Starting

CODE IDENT NO.	SIZE	
06509	A	
SCALE		SHEET



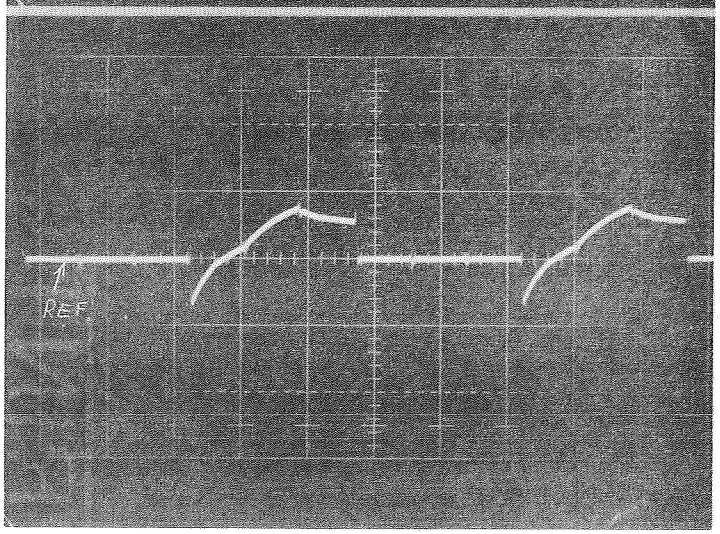
Q25 V_{CE}

FIGURE 34
Vert. = 20 Volts/Cm
Horiz. = 500 μs/Cm
Input = 50 Volts DC
Load = Running



Q25 V_{CE}

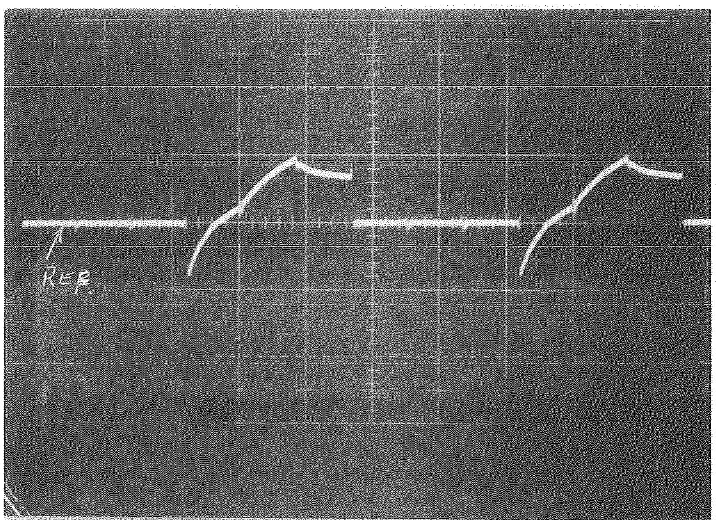
FIGURE 35
Vert. = 20 Volts/Cm
Horiz. = 500 μs/Cm
Input = 60 Volts DC
Load = Running



Q25 I_C

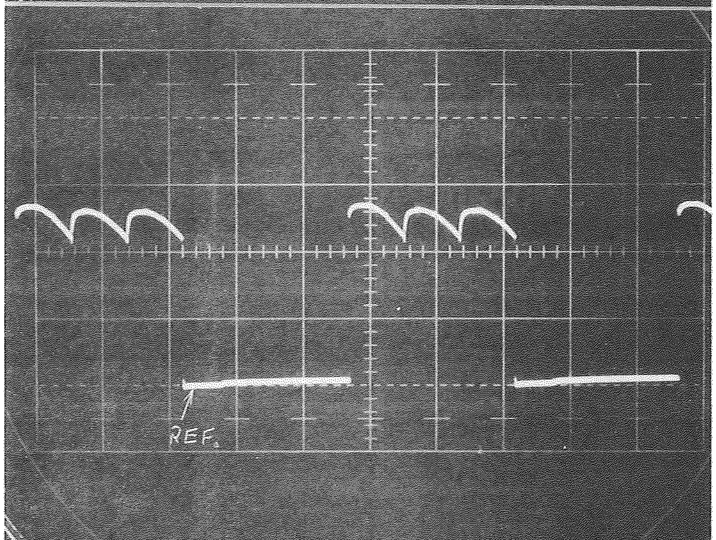
FIGURE 36
Vert. = 5 Amp/Cm
Horiz. = 500 μs/Cm
Input = 50 Volts DC
Load = Running

CODE IDENT NO.	SIZE	
06509	A	
SCALE		SHEET



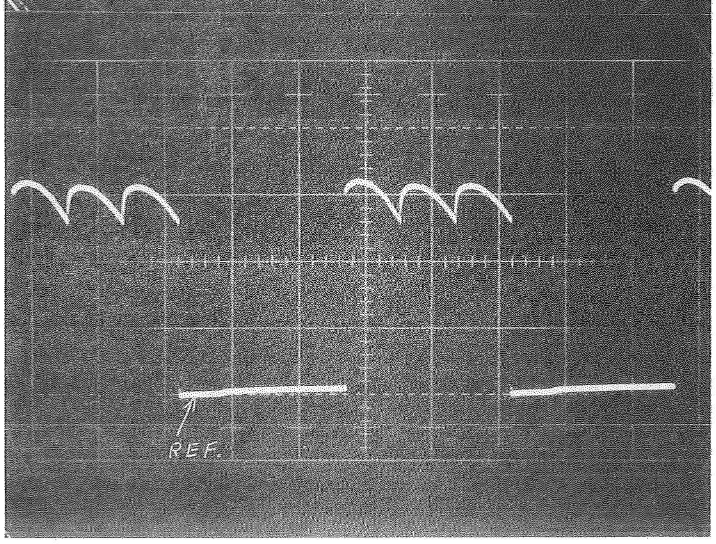
Q25 I_C

FIGURE 37
Vert. = 5 Amp/Cm
Horiz. = 500 μs/Cm
Input = 60 Volts DC
Load = Running



Q25 V_{CE}

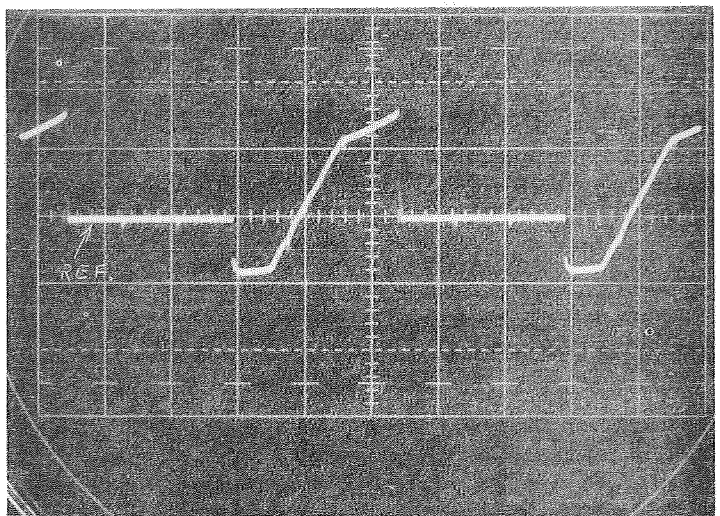
FIGURE 38
Vert. = 20 Volt/Cm
Horiz. = 500 μs/Cm
Input = 50 Volts DC
Load = Starting



Q25 V_{CE}

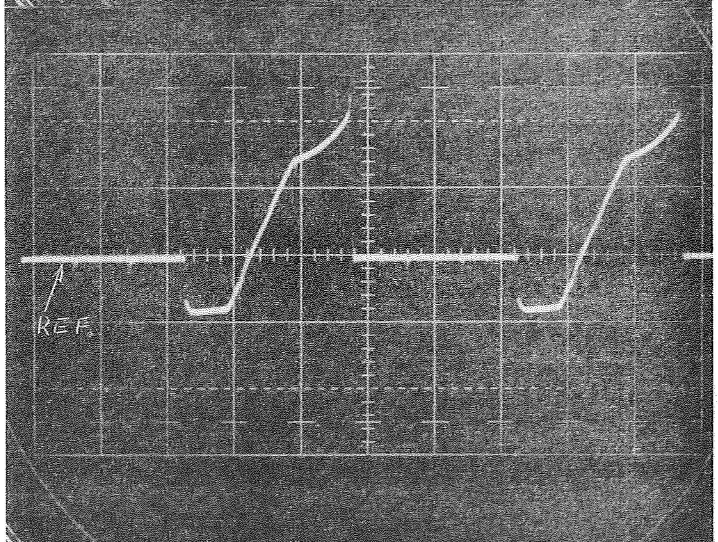
FIGURE 39
Vert. = 20 Volt/Cm
Horiz. = 500 μs/Cm
Input = 60 Volts DC
Load = Starting

CODE IDENT NO.	SIZE	
06509	A	
SCALE		SHEET



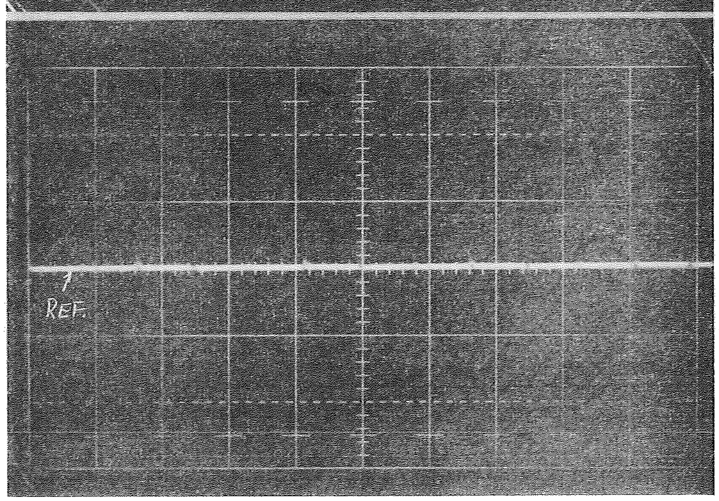
Q25 I_C

FIGURE 40
Vert. = 10 Amp/Cm
Horiz. = 500 μs/Cm
Input = 50 Volts DC
Load = Starting



Q25 I_C

FIGURE 41
Vert. = 10 Amp/Cm
Horiz. = 500 μs/Cm
Input = 60 Volts DC
Load = Starting



CR12 and 14 I_F

FIGURE 42
Vert. = 5 Amp/Cm
Horiz. = 500 μs/Cm
Input = 50 Volts DC
Load = Running

CODE IDENT NO.	SIZE	
06509	A	
SCALE		SHEET

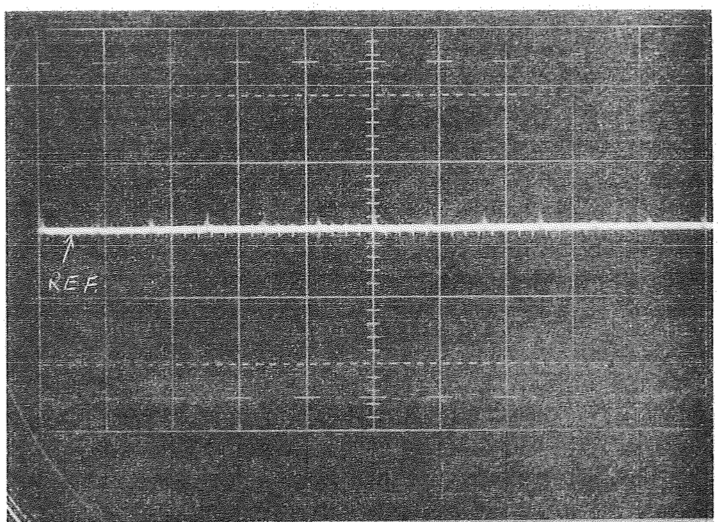


FIGURE 43
Vert. = 5 Amp/Cm
Horiz. = 500 μs/Cm
Input = 60 Volts DC
Load = Running

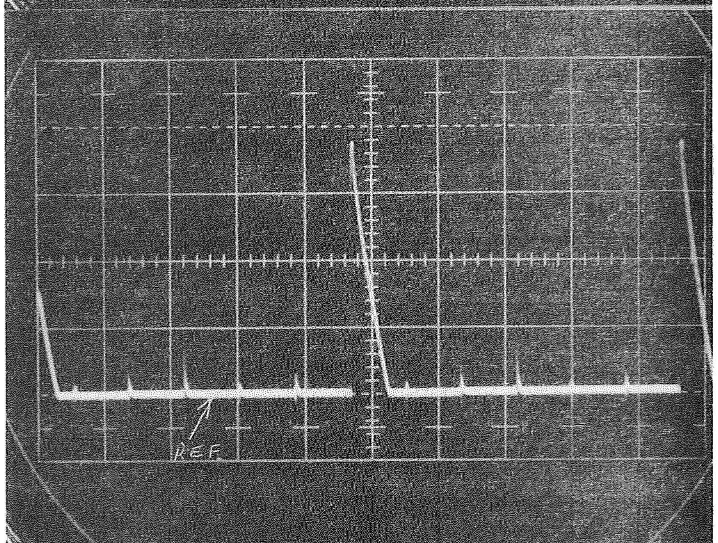


FIGURE 44
Vert. = 10 Amp/Cm
Horiz. = 500 μs/Cm
Input = 50 Volts DC
Load = Starting

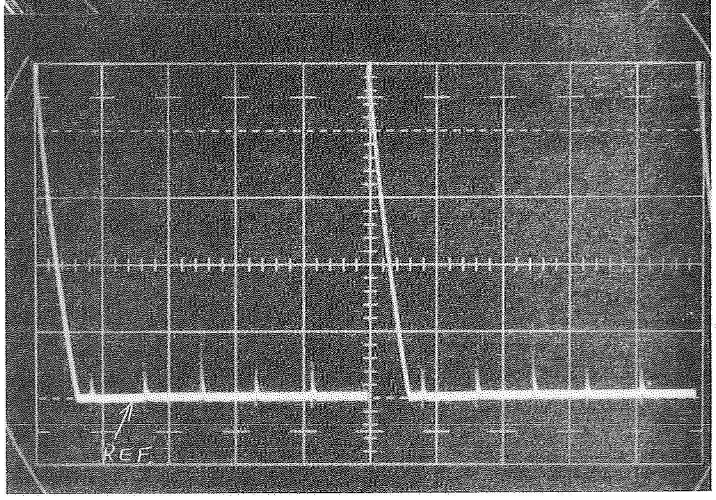


FIGURE 45
Vert. = 10 Amp/Cm
Horiz. = 500 μs/Cm
Input = 60 Volts DC
Load = Starting

CODE IDENT NO.	SIZE	
06509	A	
SCALE		SHEET

V_{CE} Vs. I_{line}

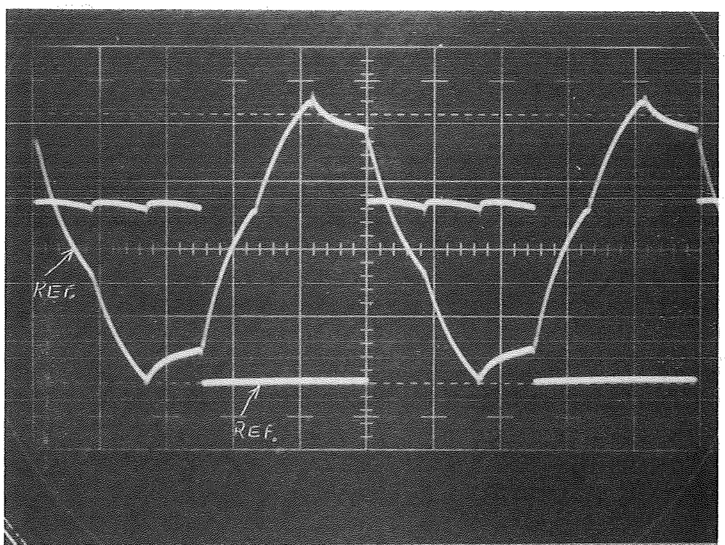


FIGURE 46
Vert. 1 = 10 Amp/Cm
Vert. 2 = 20 Volt/Cm
Horiz. = 500 μs/Cm
Input = 50 Volts DC
Load = Running

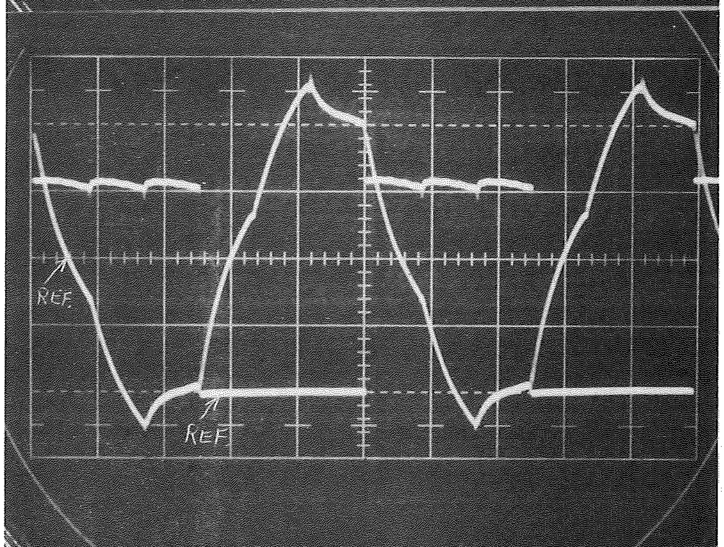


FIGURE 47
Vert. 1 = 10 Amp/Cm
Vert. 2 = 20 Volt/Cm
Horiz. = 500 μs/Cm
Input = 60 Volts DC
Load = Running

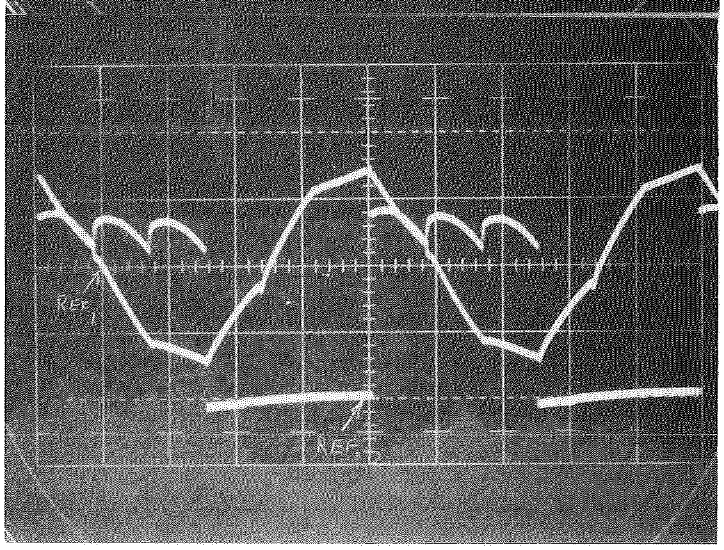


FIGURE 48
Vert. 1 = 50 Amp/Cm
Vert. 2 = 20 Volt/Cm
Horiz. = 500 μs/Cm
Input = 50 Volts DC
Load = Starting

CODE IDENT NO.	SIZE	
06509	A	
SCALE		SHEET

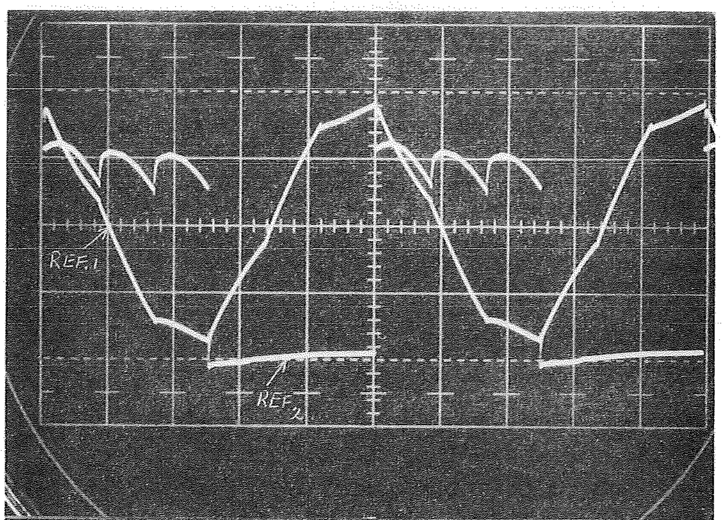


FIGURE 49
Vert. 1 = 50 Amp/Cm
Vert. 2 = 20 Volt/Cm
Horiz. = 500 μs/Cm
Input = 60 Volts DC
Load = Starting

V_{AB} Vs. I_{line}

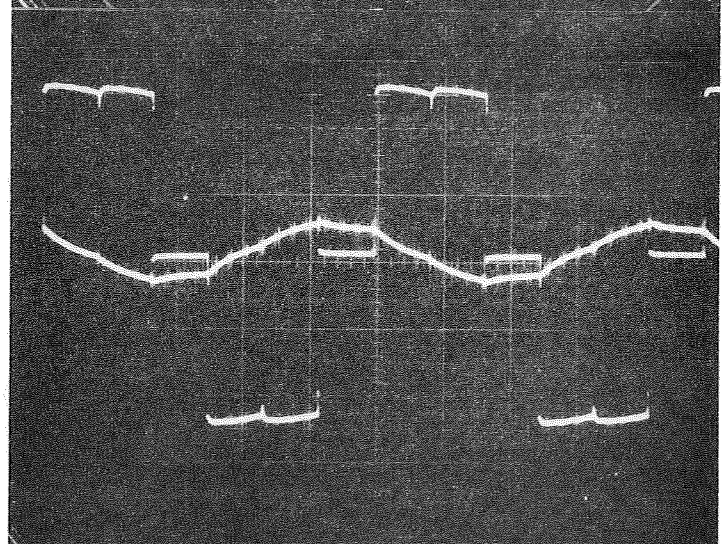


FIGURE 50
Vert. 1 = 20 Volt/Cm
Vert. 2 = 50 Amp/Cm
Horiz. = 500 μs/Cm
Input = 50 Volts DC
Load = Running

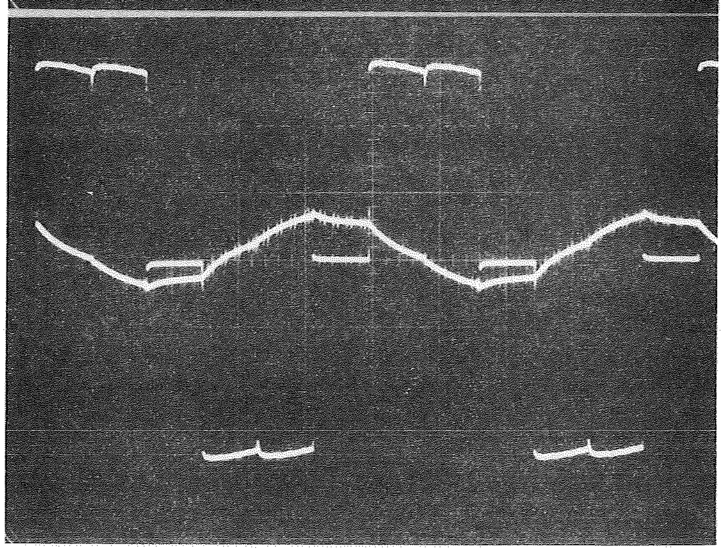


FIGURE 51
Vert. 1 = 20 Volts/Cm
Vert. 2 = 50 Amp/Cm
Horiz. = 500 μs/Cm
Input = 60 Volts DC
Load = Running

CODE IDENT NO.	SIZE	
06509	A	
SCALE		SHEET

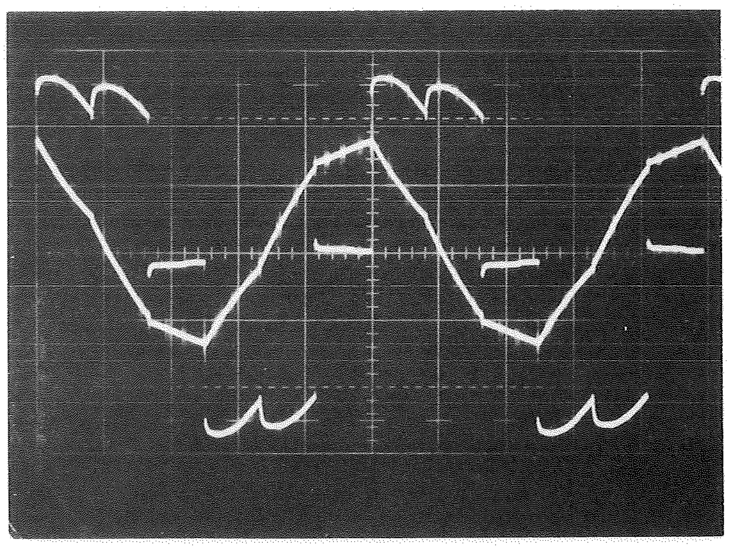


FIGURE 52
Vert. 1 = 20 Volt/Cm
Vert. 2 = 50 Amp/Cm
Horiz. = 500 μs/Cm
Input = 50 Volts DC
Load = Starting

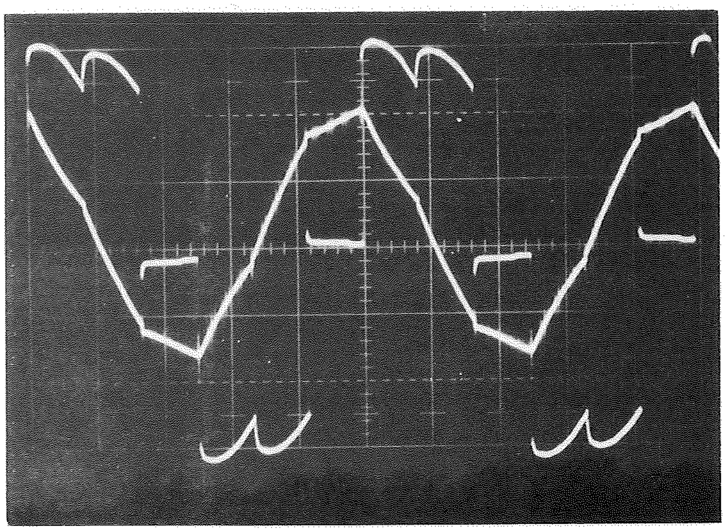


FIGURE 53
Vert. 1 = 20 Volt/Cm
Vert. 2 = 50 Amp/Cm
Horiz. = 500 μs/Cm
Input = 60 Volts DC
Load = Starting

CODE IDENT NO.	SIZE	
06509	A	
SCALE		SHEET

GULTON INDUSTRIES, INC.
Engineered Magnetics Division
ENGINEERED MAGNETICS MODEL EMIU104D

DATE 11-27-68
SERIAL NUMBER 25506
TEMPERATURE 72° F

TECHNICIAN [illegible]
ENGINEER ______
QUALITY ASSURANCE JG EM 9

1. EXAMINATION OF UNIT ✓ (Check if acceptable)
   WEIGHT 25 lbs 3 ozs lbs ([redacted] lbs maximum)
   36.0 lbs per EC 23904

2. INSULATION RESISTANCE
   CONNECTOR J1 PINS TO CASE GROUND 20K Megohms
   TERMINALS T1 through T5 to CASE GROUND 21K Megohms
   (20 megohms or greater)

3. BURN-IN ✓ (Check when completed)

4. LOW LEVEL VIBRATION
   DISCONTINUITY AND DEVIATIONS
   X AXIS ✓ None
   Y AXIS ✓ None
   (If none, state none)
   DAMAGE OR STRUCTURAL DEFORMITY
   None
   (If none, state none)
   Mechanical Engineers approval of test setup NA
   (First Article Only)

FIGURE 1. ACCEPTANCE TEST RECORD FORM.

CODE IDENT NO.	SIZE	
06509	A	712954
SCALE		SHEET 18

GULTON INDUSTRIES, INC.
Engineered Magnetics Division
ENGINEERED MAGNETICS MODEL EMIU104D

DATE 11-27-68
SERIAL NUMBER 25506
TEMPERATURE 72°F

TECHNICIAN Ed Penn
ENGINEER [illegible]
QUALITY ASSURANCE JG

5.1 OUTPUT FREQUENCY

DURING RUNNING LOAD

ØAB Output Frequency 399 Hz
ØBC Output Frequency 399 Hz
ØCA Output Frequency 399 Hz

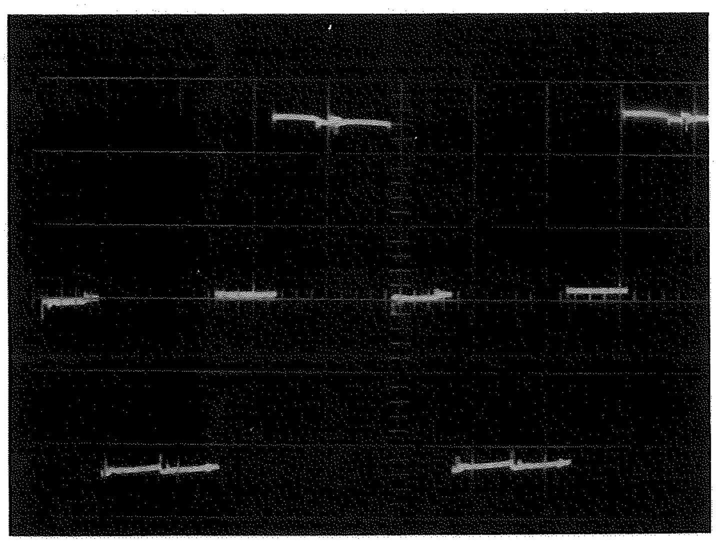
DURING STARTING LOAD

ØAB Output Frequency 399 Hz
ØBC Output Frequency 399 Hz
ØCA Output Frequency 399 Hz

ACCEPTABLE PERFORMANCE

The output frequency shall remain between 396 to 404 Hz.
The unit shall require no warm-up time.

5.2 OUTPUT WAVEFORM AND PHASE ROTATION



DURING RUNNING LOAD

DC REF Center Line*

TIMEBASE 500 μ sec C/M

V/CM 20 volts C/M

PHASE DISPLACEMENT

ØA-B 119.7 degrees.

ØB-C 120.1 degrees.

ØC-A 120.2 degrees.

PHASE ROTATION ✓.

(Check (✓) if acceptable)

ACCEPTABLE PERFORMANCE

1. The output waveform shall be a quasi-squarewave with a zero dwell time of 60 ± 5 degrees and the peaks of 120 ± 5 degrees.
2. The output phase displacement shall not exceed 120 ± 5 degrees.
3. The peak output voltage shall be approximately two volts less than the DC input voltage.
4. Phase rotation shall be A-B-C as observed by the phase rotation lights on the Load Bank.

FIGURE 2. ACCEPTANCE TEST RECORD FORM.

CODE IDENT NO.	SIZE	
06509	A	712954
SCALE		SHEET 19

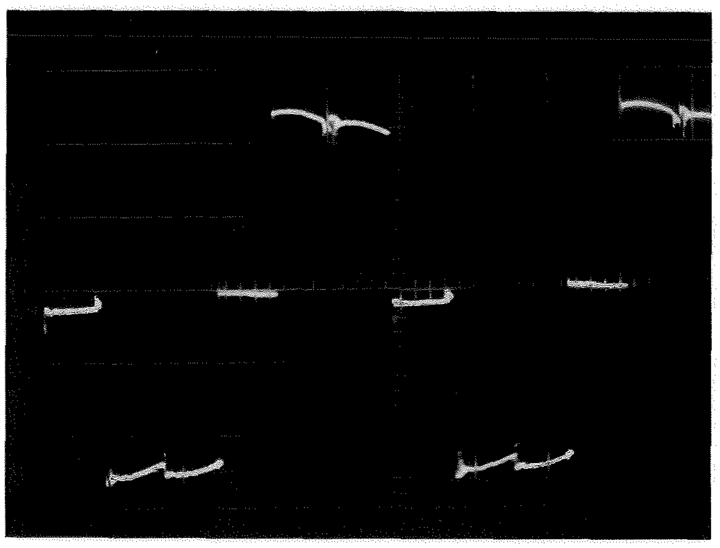
GULTON INDUSTRIES, INC.
Engineered Magnetics Division
ENGINEERED MAGNETICS MODEL EMIU104D

DATE 11-27-68
SERIAL NUMBER 25506
TEMPERATURE 72°F

TECHNICIAN [illegible]
ENGINEER [illegible]
QUALITY ASSURANCE Ja (EM 9)

5.2 OUTPUT WAVEFORM AND PHASE ROTATION (CONT'D)
3.4.3 and 3.4.8)

(ATTACH PHOTOGRAPH HERE)



DURING STARTING LOAD

DC REF Center Line

TIMEBASE 500 μsec c/m

V/CM 20 volts c/m

PHASE DISPLACEMENT

ØA-B 119.9 degrees.

ØB-C 120.1 degrees.

ØC-A 120.0 degrees.

PHASE ROTATION ✓.

(Check (✓) if acceptable)

1. The output waveform shall be a quasi-squarewave with a zero dwell time of 60 ± 5 degrees and the peaks of 120 ± 5 degrees.
2. The output phase displacement shall not exceed 120 ± 5 degrees.
3. The peak output voltage shall be approximately two volts less than the DC input voltage.
4. Phase rotation shall be A-B-C as observed by the phase rotation lights on the Load Bank.

FIGURE 3. ACCEPTANCE TEST RECORD FORM.

CODE IDENT NO.	SIZE	
06509	A	712954
SCALE		SHEET 20

GULTON INDUSTRIES, INC.
Engineered Magnetics Division
ENGINEERED MAGNETICS MODEL EMIU104D

DATE 11-27-68
SERIAL NUMBER 25506
TEMPERATURE 72°F

TECHNICIAN [illegible]
ENGINEER [illegible]
QUALITY ASSURANCE EM 9

5.3 **EFFICIENCY**

DC INPUT:

VOLTS 56 CURRENT 9.8 WATTS 548

ØA OUTPUT:

VOLTS 26.47 V^2 700 R_L 3.98 P_L 8.0 WATTS 175

ØB OUTPUT:

VOLTS 26.34 V^2 693 R_L 3.98 P_L 10.0 WATTS 171

ØC OUTPUT:

VOLTS 26.50 V^2 702 R_L 3.98 P_L 8.0 WATTS 176

EFFICIENCY: 95.2 %

ACCEPTABLE PERFORMANCE

The efficiency shall not be less than 85 percent at RUNNING LOAD.

5.4 OVERLOAD

ØA OUTPUT CURRENT 29.5 AMPS
ØB OUTPUT CURRENT 30.0 AMPS
ØC OUTPUT CURRENT 29.5 AMPS

ACCEPTABLE PERFORMANCE

The output current shall be approximately 51 amps per phase at 56 VDC input.

FIGURE 4. ACCEPTANCE TEST RECORD FORM.

CODE IDENT NO.	SIZE		
06509	A	712954	
SCALE			SHEET 21

GULTON INDUSTRIES, INC.
Engineered Magnetics Division
ENGINEERED MAGNETICS MODEL EMIU104D

DATE 11-27-68 TECHNICIAN Ed Perin
SERIAL NUMBER 25506 ENGINEER [illegible]
TEMPERATURE 72°F QUALITY ASSURANCE [illegible]

5.5 OUTPUT INSTRUMENTATION

ØCA Output Voltage 45.19 VAC rms STARTING LOAD
46.46 VAC rms RUNNING LOAD
ØA-C Output Voltage Sense 4.374 VDC STARTING LOAD
4.491 VDC RUNNING LOAD
ØA-C Output Voltage Sense Ripple 3.4 MV RMS (5 RMS MAX.) STARTING LOAD
3.3 MV RMS (5 RMS MAX.) RUNNING LOAD
Output Voltage Sense Accuracy Calculation:
(0.1 X ØCA Output Voltage VAC rms = ØA-C Output Voltage Sense
VDC ± 0.30) 0.1x 45.19 = 4.519 STARTING LOAD
0.1x 46.46 = 4.646 RUNNING LOAD
ØA-C Output Voltage Sense (Check if acceptable) ✓. STARTING LOAD
(Check if acceptable) ✓. RUNNING LOAD
ØAB Output Voltage 45.16 VAC rms STARTING LOAD
46.26 VAC rms RUNNING LOAD
ØA-B Output Voltage Sense 4.360 VDC STARTING LOAD
4.433 VDC RUNNING LOAD
ØA-B Output Voltage Sense Ripple 3.4 MV RMS (5 MV RMS MAX.) STARTING LOAD
3.3 MV RMS (5 MV RMS MAX.) RUNNING LOAD
Output Voltage Sense Accuracy Calculation:
(0.1 X ØAB Output Voltage VAC rms = ØA-B Output Voltage Sense
VDC ± 0.30) 0.1x 45.16 = 4.516 STARTING LOAD
0.1x 46.26 = 4.626 RUNNING LOAD
ØA-B Output Voltage Sense (Check if acceptable) ✓. STARTING LOAD
(Check if acceptable) ✓. RUNNING LOAD
Frequency Signal Amplitude 6.8 (6.25 + 1.400 - 0.000 V P-P) STARTING LOAD
6.8 (6.25 + 1.400 - 0.000 V P-P) RUNNING LOAD
Waveform (Check if acceptable) ✓ (Square wave) STARTING LOAD
(Check if acceptable) ✓ (Square wave) RUNNING LOAD
Frequency 399 Hz (400 Hz nominal) STARTING LOAD
399 Hz (400 Hz nominal) RUNNING LOAD

FIGURE 5. ACCEPTANCE TEST RECORD FORM.

CODE IDENT NO.	SIZE	
06509	A	712954
SCALE		SHEET 22

OPERATION RECORD

DRAWING NO. 514100 SHEET 1 OF 7

EQUIP NAME: Static Power Inverter | ITEM MODEL NO: EM1U104D | ITEM SERIAL NO: 25506 | CUSTOMER SPEC NO: | CUSTOMER DRAWING NO:

GROUND LIFE LIMIT: SEC | MIN | HRS | CYS

TEST DATES AND OPERATING TIME

START DATE YR 1968 MO	DA.	STOP DATE YR 1968 MO.	DA	OPERATING TIME CYS HRS.	MIN.	SEC	ACCUMUL. TIME CYS HRS	MIN	SEC	TEST AREA	TYPE OF TEST, SYSTEM RUN, BENCH, ETC	TEST PROC NO	BUY OFF EE	QC
11	13	11	13	1	30		1	30		EM	SIT	712954	[illegible]	
11	19	11	19		10		1	40		EM	T-OM	"	[illegible]	
11	19	11	19		15		1	55		EM	T-OM	"	[illegible]	EM
11	20	11	25	100			101	55		EM	Break in	"	[illegible]	
11	25	11	25		20		102	15		EM	VIB	"	BV	EM
11	27	11	27		30		102	45		EM	ATP	712954	[illegible]	

FIGURE 6. ACCEPTANCE TEST RECORD FORM.

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